NATIONAL WEB-SEMINAR

ON

Natural Resource Conservation and Management

March 20-22, 2021

SOUVENIR cum ABSTRACTS

Organized by

Academy of Natural Resource Conservation and Management (ANRCM)

Lucknow, Uttar Pradesh

National Web Seminar

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NATIONAL WEB SEMINAR

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Editors

- Y.P. Singh
- T.K. Srivastava
- Sanjay Arora
- A.K. Singh

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Organized by

Academy of Natural Resource Conservation and Management
#3/35 Virat Khand,
Gomti Nagar, Lucknow, Uttar Pradesh
Contact: +91-7376277190; 876512394
Email: anrcm.india@gmail.com

CONTENT

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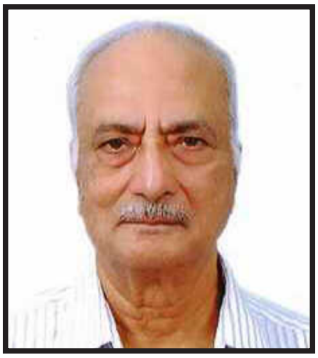
ACADEMY OF NATURAL RESOURCE CONSERVATION AND MANAGEMENT
(ANRCM)
www.anrcm.org

Registered Office: #3/35 Virat Khand, Gomti Nagar, Lucknow 226010 (U.P.)

Dr. G.B. Singh
Chief Patron, ANRCM
Ex-DDG (NRM), ICAR
Ex-Vice-Chancellor,
JNKVV, Jabalpur and
Ex-Director General, UPCAR



MESSAGE

Land, water, soil and vegetation are the most important natural resources which need to be managed scientifically for sustainable development and to mitigate on site and off site effects on natural system. Conserving earth's biological diversity and safeguarding the benefits of ecosystem services are the two major objectives of natural resource management and conservation. Natural resource management is a multi-disciplinary field that integrates the complex interrelationship among soil, plant, animal, human and the environment. India is blessed with vast natural resources ***viz.*** land, water, vegetation, human and livestock, but their unplanned and unscientific exploitation has led to serious environmental and land degradation processes. Climate change is one of today's most emerging global issues and will become increasingly important in the decades to come, a matter of concern. It can entail an increase in climatic variability, extreme events and shocks, and threaten livelihood security of millions of people. Its impacts are cross cutting in all sectors and walks of life; however, agriculture sector is among the most vulnerable sectors to the impacts of climate change. Protection and improvement of land, water, biodiversity and climate resources are pre-requisite for sustainable agriculture in the context of changing climate scenario. Comprehensive and effective adaptation and mitigation measures to enhance resilience to climate change are need of hour. Diversified research on how the environmental changes in general and climate changes in particular will affect the drivers of mitigation and livelihood loss and how it can be addressed in holistic angle including policy framing.

In this context, a National Web Seminar dedicated for discussing issues, challenges and framing strategies for resource management that is being organized on March 20-22, 2021 by Academy of Natural Resource Conservation and Management at Lucknow (U.P.) is very timely. I believe that the efforts made by Academy of Natural Resource Conservation and Management to organize National Web Seminar will surely bring out plan for efficient management of natural resources vis-à-vis mitigating climate change effects and uplifting farmers income.

I extend my warm wishes to the participants and the organizing team of the Seminar.

(G.B. Singh)

सत्यमेव जयते
त्रिलोचन महापात्र, पीएच.डी.
सचिव, एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001
GOVERNMENT OF INDIA
DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION
AND
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
MINISTRY OF AGRICULTURE AND FARMERS WELFARE
KRISHI BHAVAN, NEW DELHI 110 001
Tel.: 23382629; 23386711 Fax: 91-11-23384773
E-mail: dg.icar@nic.in

MESSAGE

I am happy to know that a National Web-Seminar is being organized by Academy of Natural Resource Conservation and Management on "Natural Resource Conservation and Management" on March 20-22, 2021.

Natural resources are critically important components of life support system, the efficient conservation and management of which are vital for sustainable agriculture and rural development. With increasing demand on land for agriculture, increase in population, urbanization, industrialization and other non-farm uses of farm lands, diversion of land resources takes place not only from wastelands but also from agriculturally and ecologically significant areas. The soil and water conservation technologies play major role for mitigating the impact of climate change on yield of various crops. The degradation of natural resources, soil and water has become a matter of serious concern for the farmers, researchers, academicians, scientists and policy makers, as these in turn affects socio-economic upliftment of rural population and sustaining agricultural productivity. I am confident that deliberations during the Web-Seminar will culminate in developing strategies and an action-oriented road map to promote conservation of natural resources and actions for combating the adverse effect of climate change.

I convey my best wishes for the success of National Seminar.

(T. MOHAPATRA)

भारतीय कृषि अनुसंधान परिषद
कक्ष क्र. 101, कृषि अनुसंधान भवन–II, पूसा, नई दिल्ली – 110 012, भारत
Indian Council of Agricultural Research
Room No. 101, Krishi Anusandhan Bhavan-II, Pusa, New Delhi - 110 012, INDIA

डॉ. सुरेश कुमार चौधरी / Dr. Suresh Kumar Chaudhari
उप महानिदेशक (प्राकृतिक संसाधन प्रबंधन)
Deputy Director General (Natural Resource Management)

Date : 22/02/2021

MESSAGE

Soil and water conservation technologies have been the major driving force for increasing agricultural productivity and development of nation. In the context of climate change scenario, the soil and water resource conservation technologies plays major role for mitigating climate change impact on crop yields. In the past, the choice of technologies and their adoption was to reduce the soil erosion, rehabilitating degraded lands and enhance the soil moisture retention and subsequent enhancement in yield. There is urgent need to protect, conserve and develop the natural resources and use them on sustainable basis to alleviate stress, enhance livelihood security, environmental stability and improve the quality of life.

A National Web Seminar dedicated for discussing issues, challenges and framing strategies for resource management that is being, organized on March 20-22, 2021 by Academy of Natural Resource Conservation and Management (ANRCM) at Lucknow (U.P.) is surely a need in present context when the Government of India is concerned for soil health, water management and enhancing income of the farmers.

I believe that the efforts made by Academy of natural Resource Conservation and Management to organize National Web Seminar will surely bring out plan for sustainable agriculture through efficient management of natural resources.

I extend my warm wishes to the participants and the organizing team.

(S. K. Chaudhari)

Phone : +91-11-2584 8364
Fax : +91-11-2584 8366
E-mail : ddg.nrm@icar.gov.in
Website : www.icar.org.in

भारतीय कृषि अनुसंधान परिषद

कृषि अनुसंधान भवन–1, पूसा, नई दिल्ली 110 012

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

Krishi Anusandhan Bhawan, Pusa, New Delhi–110 012

Mob.: 91-11-25843277 (O), Fax : 91-11-25842968

E-mail: aksicar@gmail.com

डा. अशोक कुमार सिंह

उप महानिदेशक (कृषि प्रसार)

Dr. A.K. Singh

Deputy Director General (Agricultural Extension)

MESSAGE

I am happy to learn that the National Seminar on Natural Resource Conservation and Management is being organized by Academy of Natural Resource Conservation and Management, Lucknow on March 20-22, 2021.

Natural resources are critically important components of life support system, the efficient conservation and management of which are vital for achieving food and livelihood security with economic growth and rural development. The degradation of our natural resources, soil and water has become a matter of serious concern for the farmers, researchers, academicians, scientists and policy makers, as these in turn affect issues like food security and livelihood. Soil and water management in the changing climate is a pre-requisite for sustainable agriculture production. The social, economic, environmental and political impacts are significant to achieve sustained agricultural growth.

I am confident that the National Web Seminar will provide a unique platform to the delegates to deliberate on different approaches of natural resource management to mitigate the problems of climate change vis-a-vis rural development to enhance food and livelihood security.

I wish the conference will be a grand success.

(A.K. Singh)

Date : 06.03.2021

डॉ० राजेन्द्र प्रसाद केन्द्रीय कृषि विश्वविद्यालय
पूसा (समस्तीपुर) - 848 125, बिहार
Dr. Rajendra Prasad Central Agricultural University
Pusa (Samastipur) – 848 125, Bihar

डॉ० रमेश चन्द्र श्रीवास्तव
कुलपति
Dr. R. C. Srivastava
M.Tech., Ph.D. (IIT, Kgp)
FNAAS, FIASWC, FISAE, FIE, FCHAI
Vice-Chancellor

Phone : 06274-240226(O)
06274-240264 (R)
Fax : 06274-240255
Mob. : 09040033323
Email : vc@rpcau.ac.in
website : www.rpcau.ac.in

No. ..... / Dr.RPCAU (VC)

Date : 27/02/2021

MESSAGE

I am delighted to know that the Academy of Natural Resource and Conservation (ANRCM), Lucknow is organizing a "National Web Seminar on Natural Resource Conservation and Management" on 20th to 22nd March, 2021. The natural resources, especially water and soil, are the basic requirement for the agricultural production and overall social and environmental sustainability. Agriculture accounts for roughly 70% of total freshwater withdrawals globally and also contributes to water pollution due to nutrient and pesticide run-off and soil erosion. Moreover, the Climate change i.e. changes in the seasonal timing of rainfall and snow pack melt, frequent occurrence of droughts and floods is causing disproportionate water supply for farming.

The Agriculture production needs to be enhanced on continuous basis in order to ensure food security for growing population, which requires sustainable management of natural resource base through practices that encourage the protection and restoration of water sources and promote water use optimization; foster soil conservation and improved carbon stocks, waste water treatment for reuse and reduction/ recycling of waste.

I am confident that the deliberations and discussions during the souvenir will come out with useful recommendations that may help in developing strategies for future research and an action oriented road map for Natural Resource Conservation and Management.

I wish for the grand success of this National Seminar and publication of the Souvenir cum abstract book.

Srivastava

(R.C. Srivastava)

डा. बिजेन्द्र सिंह
कुलपति
महानिदेशक, उपकार
Dr. Bijendra Singh
Vice-Chancellor
Director General (UPCAR)

आचार्य नरेन्द्र देव कृषि एवं प्रौद्योगिक विश्वविद्यालय
कुमारगंज, अयोध्या–224 229 (उ0प्र0) भारत
Acharya Narendra Deva University of Agriculture & Technology
Kumarganj, Ayodhya-224 229 (U.P.) India

No.01/PS-VC/Message/2021/508 Dated : 24.02.2021

MESSAGE

It gives me immense pleasure to know that the Academy of Natural Resource Conservation and Management, Lucknow is organizing 3 days National We Seminar on **"Natural Resource Conservation and Management"** from March, 20-22, 2021. The seminar provides an excellent platform to the researchers, academicians, students and progressive farmers to hold discussions and share new ideas on this important subject.

Natural resources provide fundamental life support, in the form of both consumptive and public-good services and are also the backbone of a country's survival and economy. Resources like air, water, and soil are the fundamentals on which life is sustainable on earth. Scientific advances in this field of research have great potential in devising novel strategies to mitigate the effects of climate change on natural resources and provide climate resilient technologies and solutions for long term sustainability of environment. The most important challenge to natural resources conservation and management is to understand their limitation. In other words we can say that natural resources are very limited & not the endless supply.

I am confident that the deliberations to be made during the seminar will be able to address these issues very elaborately.

I congratulate and compliment the organizing team on this occasion and convey my best wishes for the success of this web seminar.

(Bijendra Singh)

Phone : +91-5270-262161(O), **Telefax**-262097(O) 262842 (R) **Telefax:**262032 (R) **E-mail:** vcnduat2018@gmail.com

डॉ. यू. एस. गौतम
कुलपति
Dr. U. S. Gautam
Vice Chancellor

बाँदा कृषि एवं प्रौद्योगिक विश्वविद्यालय
बाँदा-210001, उ.प्र., भारत
BANDA UNIVERSITY OF AGRICULTURE & TECHNOLOGY
BANDA-210001, U.P., INDIA

Date : 7/3/2021

MESSAGE

Soil and Water resources are critically important components of life support system, the efficient conservation and management of which are imperative for achieving food and livelihood security with economic growth and rural development. It is indeed time to rethink the way in which we take care of the earth and its resources. Resource conservation is a holistic approach to agriculture that can play an important role in addressing the challenges to food security.

I am happy to note that the National Web Seminar on Natural Resource Conservation and Management is being organised on 20-22 March, 2021 at Lucknow (U.P.), endeavors to focus on conservation and management of soil and water resources to enhance food and livelihood security. It is earnestly hoped that the delegates of this National Seminar that include researchers, academicians, scientists, extension workers, students, policy makers and all other stakeholders will get benefitted from the deliberations and also come out with concrete recommendations for conservation and management of soil and water resources.

On this occasion I extend my greetings and felicitations to all those associated with the Seminar and wish all success.

(U. S. Gautam)

Office No. 05192-232305, email: vc.buat@gmail.com, vcbuat.bn-up@gov.in, Website: www.buat.edu.in

भाकृअनुप केंद्रीय मृदा लवणता अनुसंधान संस्थान
ICAR - Central Soil Salinity Research Institute

Zarifa Farm, Kachawa Road, Karnal – 132001 (India)

Dr. P.C. Sharma
Director

MESSAGE

With great pleasure I learn that the National Seminar on Natural Resource Conservation and Management in being organized by Academy of Natural Resource Conservation and Management, Lucknow on March 20-22, 2021.

Natural resources are critically important components of life support system, the efficient conservation and management of which are vital for achieving food and livelihood security with economic growth and rural development. The degradation of our natural resources, soil and water has become a matter of serious concern for the farmers, researchers, academicians, scientists and policy makers, as these in turn affect issues like upliftment of rural people, food security and livelihood. Soil and water management in the changing climate is a pre-requisite for sustainable agriculture production. The social, economic, environmental and political impacts are significant to achieve sustained agricultural growth.

I am confident that the National Web Seminar will provide a unique platform to the delegates to deliberate on different approaches for natural resource management to mitigate the problems of climate change vis-a-vis rural development to enhance food and livelihood security.

I wish the conference will be a grand success.

(P. C. Sharma)

भाकृअनुप-भारतीय गन्ना अनुसंधान संस्थान
रायबरेली रोड, पोस्ट दिलकुशा, लखनऊ-226 002, भारत
ICAR - INDIAN INSTITUTE OF SUGARCANE RESEARCH
Rae Bareli Road, Post Dilkusha, Lucknow-226 002, India

डॉ० अश्विनी दत्त पाठक
निदेशक
Dr. Ashwini Dutt Pathak
Director

MESSAGE

I am delighted to learn that Academy of Natural Resource Conservation and Management, Lucknow (U.P.) is organizing National Web Seminar on Natural Resource Conservation and Management on March 20-22, 2021.

Soil and water are precious natural resources for sustainability of agriculture and environment and needs their conservation as there is immense pressure on these resources due to ever increasing population and to meet its growing demand for food, fiber, fodder, fuel and shelter. Soil and water resources are being deteriorated due to different anthropogenic and natural factors. Soil erosion is one of the major deteriorative processes which results in deterioration of the soil and may lead to the significant loss of soil productivity and desertification under severe conditions. It is pertinent to protect the soil resources against erosion for sustainable agriculture and environment by adopting different control measures and innovative technologies. The concept of soil conservation cannot be materialized without conserving and efficient use of water resources. Thus, it is essential to practice soil and water conservation practices including soil management, crop management, engineering, range management and agro forestry operation. I would like to congratulate the organizers for debating on such an important theme.

I am sure that the deliberations and discussions during the National Web Seminar will come out with some useful recommendations that may help in developing strategies and action oriented road map for conservation and management of natural resources for sustainable production.

I wish the National Web Seminar a grand success.

(A. D. Pathak)

Telephones : +91-522-522-2480726 **(Off.) EPBAX :** +91-522-2491802
Telefax : +91-522-2480738 **E-mail :** director.sugarcane@icar.gov.in, pathakashwini@rediffmail.com

भा.कृ.अनु.प.-केन्द्रीय उपोष्ण बागवानी संस्थान
रहमानखेड़ा, डाकघर काकोरी, लखनऊ-226 101 (भारत)
ICAR-Central Institute for Subtropical Horticulture
Rehmankhera, P.O. Kakori, Lucknow - 226 101 (India)

MESSAGE

I am glad to know that the Academy of Natural Resource Conservation and Management is hosting a National Web Seminar on "Natural Resource Conservation and Management" on 20-22 March, 2021 at Lucknow. It gives me immense pleasure to know that a Souvenir is also being published on this occasion.

As I understand, this Seminar will be attended by scientists, researchers, academicians, extension field functionaries, farmers and students. I hope the discussion during the seminar will put forward some innovative approaches and feasible techniques for conservation of soil and water resources.

It is my pleasure to wish the organizers and participants for the success of this seminar.

My best wishes for successful seminar.

(Shailendra Rajan)
Director

Dated : 13.03.2021

CSIR-CIMAP

सीएसआईआर-केन्द्रीय औषधीय एवं सगंध पौधा संस्थान
(वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्)
कुकरैल पिकनिक स्पॉट रोड, पी.ओ.-सीमैप, लखनऊ-226 015, उ.प्र., भारत

CSIR-Central Institute of Medicinal and Aromatic Plants
(Council of Scientific & Industrial Research)
Kukrail Picnic Spot Road, P.O. CIMAP, Lucknow-226 015, U.P., India

डॉ. प्रबोध कुमार त्रिवेदी, एफएनए, एफएनएएससी, एफएनएएएस
निदेशक

Dr. Prabodh Kumar Trivedi, FNA, FNASc, FNAAS
Director

Date: 22/02/2021

MESSAGE

It is a matter of immense pleasure for me to know that the Academy of Natural Resource Conservation and Management (ANRCM) is organizing a National Web Seminar on "Natural Resource Conservation and Management" during 20th to 22nd March, 2021. This seminar is very timely and will be providing a common platform to researchers, academicians, scholars, progressive farmers, technologists, industry and other stakeholders enabling them to interact among themselves. The natural resources are required to be utilized by mankind in a sustainable manner. The burgeoning population and consequent anthropogenic activities pose a severe challenge to the conservation and management of natural resources like water, soil, atmosphere, flora, fauna, etc. Evidently, the theme of the seminar is focused towards initiating a deliberation on finding means to meet the natural resource sustainability challenges. I am confident that the seminar will be a great success with the proven track record of the organizers from ANRCM in natural resource management and conservation. It will also be able to provide guidelines for policy formulation for environmental safety aspects and natural resource sustainability. I would also like to take this opportunity to invite the delegates to visit the healthy and aromatic campus of CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP) during their visit to scientifically rich city of Lucknow. Finally, I wish great success for the seminar and hope that it would be scientifically fruitful to all the participants.

(Prabodh K. Trivedi)

Phone : +91-522-2718505, 2719083, 9415006799; Fax + 91-522-2718695, 2716141; E-mail: director@cimap.res.in
HQ. Lucknow; **Research Centres :** Bengaluru, Hyderabad, Pantnagar, Purara
www.cimap.res.in

ACADEMY OF NATURAL RESOURCE CONSERVATION AND MANAGEMENT
(ANRCM)

Regd No. LUC/04155/2019-2020

Registered Office: #3/35 Virat Khand, Gomti Nagar, Lucknow 226010 (U.P.)

F. No./ANRCM/2020-21/ Date: 08/03/2021

Dr. Sanjay Arora
Organizing Secretary, National Seminar &
Secretary, ANRCM

MESSAGE

Natural resources especially soil and water have been remained an important component of not only the agro-ecosystem but also the biosphere. However, over the time, these resources have degraded and depleted over the time in the absence of their judicious scientific and systematic management coupled with their non-judicious use. The degradation of soil and water resources has been started threatening the agricultural sustainability globally. The changing climatic conditions have further aggravated the issue leading to degradation of soil at higher rates than envisaged earlier. Similarly, the water resources have been depleted at higher rates due to erratic, uncertain rains at most of the places in the world. The effects have been much more conspicuous in the less developed or under developed countries. This has thus become a matter of serious concern for the farmers, scientists and policy makers in such countries.

The national seminar on the important theme expects to bring the scientists, academicians and experts from different agro-ecological regions at one platform to address the issues and challenges of soil and water resources management particularly under changing climatic conditions. It was earlier proposed to be held in physical mode at ICAR-NBFGR, Lucknow during March 20, 2020, but due to corona pandemic it was deferred. I appreciate the patience of the registered participants.

The National Web Seminar is now being organized during March 20-22, 2021 with the same theme and with the motive to celebrate World Water Day on March 22, 2021.

I take this opportunity to welcome one and all to participate in the National Web Seminar.

(Sanjay Arora)

ARTICLES

STATUS OF SOIL ORGANIC CARBON STOCK (SOC) IN UTTAR PRADESH AND STRATEGIES FOR IMPROVEMENT

R. P. Sharma[1], Nirmal Kumar[2], S. K. Singh[3] and Sanjay Arora[4]

Introduction

Soil carbon storage is the third largest carbon pool in the Earth System and plays an important role in the global carbon cycle and climate change (Lal and Kimble, 2000). The majority of carbon, in most soils, is held as soil organic carbon (SOC) whereas in soils of the arid and semi-arid regions, the most common form is inorganic carbon, primarily carbonates (Eswaran *et al*., 2000). Quantifying both SOC and soil inorganic carbon (SIC) is essential to our understanding of the carbon cycle at regional to global scales. Soil organic matter is an important component that regulates most of the soil properties. It is a prominent indicator for assessing soil quality and climate change phenomenon. Climate change is attributed to increase in atmospheric concentration of several greenhouse gases (GHGs) by fossil fuel combustion, land use change, deforestation and human induced soil degradation (Solomon *et al*., 2007).

In the recent past, the greenhouse effect has been of great concern, and has led to several studies on the quality, kind, distribution and behaviour of SOC (Velayutham, 2000). Management of both SOC and SIC pools in semi-arid ecosystems can play a major role in reducing the rate of enrichment of atmospheric CO_2. The term soil C sequestration implies transfer of atmospheric CO_2 into soil C pool through humification of crop residue and formation of secondary carbonates or bicarbonates. The SOC pool includes highly active humus and relatively inert charcoal C. The SIC pool includes elemental C and carbonate minerals (e.g., gypsum, calcite, dolomite, aragonite, and siderite). Soil is the vital foundation of terrestrial ecosystems storing water, nutrients, and almost three-quarters of the organic carbon stocks of the Earth's biomes. Soil organic carbon (SOC) stocks vary with land-cover and land-use change, with significant losses occurring through disturbance and cultivation (Edmondson *et al*., 2014). All over the world including India, most of the soil carbon stock based studies has been conducted with lesser number of observations of soil profiles per unit area. The first comprehensive study of organic carbon (OC) status in Indian soils was conducted by Jenny and Raychaudhuri (1960). They studied 500 soil samples collected from different cultivated fields and forests with variable rainfall and temperature patterns. The study confirmed the effects of climate on carbon reserves in the soils. However, these authors did not make any estimate of the total carbon reserves in the soils. The first attempt in estimating OC stock was made by Gupta and Rao (1994). They reported OC stock of 24.3 Pg (1 Pg = 1015g) for the soils ranging from surface to an average subsurface depth of 44 to 186 cm with the database of 48 soil series. However, this estimate was based on a hypothesis of enhancement of OC level judging by success stories of afforestation programmes on certain unproductive soils. An attempt has also been made to estimate the SOC stock in physiographic regions by NATMO (1980). Bhattacharyya *et al*. (2000) computed 63 Pg SOC in various physiographic regions of India in first 150 cm depth of soils with their geographical distribution through the country. Intensive agriculture without proper management may cause of rapid SOC depletion in cropland as compared to untilled soils. Excessive tillage and intensive cultivation in semi-arid region

[1]Senior Scientist, ICAR-National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur, Maharashtra-440033 (e-mail address: rpsharma64@yahoo.com)

[2]Senior scientist, ICAR-National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur, Maharashtra-440033

[3]Ex Director, ICAR-National Bureau of Soil Survey and Land Use Planning, Amravati Road, Nagpur, Maharashtra-440033

[4]Principle Scientist, ICAR-CSSRI, Regional Research Station, Lucknow (U.P.)

reduced soil organic carbon density from 60 kg/km² under single cropping to 10.5 kg/km² under double cropping (Singh *et al*., 2007).Recently, Sharma and Singh (2015) computed SOC and SIC stocks in three physiographic units *viz.* Eastern plain, Aravalli and Vindhyan landscape comprised of 40 soil series of Rajasthan. To sustain the quality and productivity of soils, knowledge of SOC and SIC both in terms of its amount and quality is essential. Therefore, we should identify organic carbon storage and maintenance strategies for Uttar Pradesh.

SOC stock in Uttar Pradesh

Global carbon map indicated that India has low carbon stock than many south Asian countries including Sri Lanka, China, Bangladesh, and Afghanistan. Soil organic carbon stock of surface layer for all district of Uttar Pradesh has been estimated by ICAR-NBSS&LUP and linked with global carbon data base. Soil carbon map of Uttar Pradesh indicate that northern part of Saharanpur district capable to maintain relatively higher SOC stock (30-35 t/ha). Part of Saharanpur, Bijnor, Rampur, Pilhibhit, Kheri, Balrampur, Siddharthnagar, Maharajganj, Kushinagar, Chandoli andSonbhadracapable to maintain moderate SOC stock (25-30 t/ha). Majority of districts of state (Fig. 1) are under low (20-25 t/ha) to very low (15-20 t/ha) in SOC stock. Mathura, Agra, Mahamayanagar, Jalaun, Jhansi, Hamirpur, Mahoba, Kanpur, Fatehpur, Kanpur Dehat, Auraiya and Chitrakoot are more vulnerable with respect to SOC stock. A quick action may be taken to restore the organic carbon in these vulnerable districts as per the 10 steps strategies.

Potential crop zones for building of SOC stock

Intensifying crop production and addressing climate change must be done in an integrated and sustainable way. ICAR-NBSS&LUP, Nagpur delineated the district wise spread and productivity (Fig. 2-4) of rice, wheat and sugarcane of UP. Bureau also delineated the potential areas of these crops in state. Line department of state should launch a massive programme to set up a land use as per the potential crop zone for stopping the existing carbon loss. It will maintain the existing carbon status and such effective management of agricultural ecosystems contributes to both climate change adaptation and climate change mitigation. It is critical for the sustainable intensification of crop production in Uttar Pradesh. The key message for line departments is to cultivate the potential crops and varieties in associations

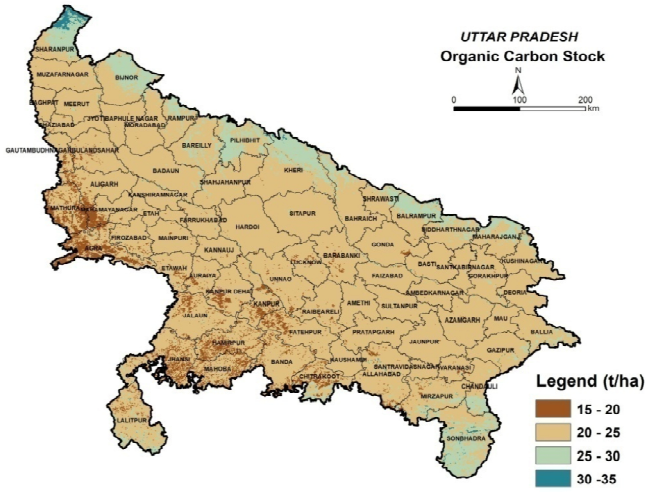


Fig. 1. Soil Organic Carbon (SOC) stock of Uttar Pradesh

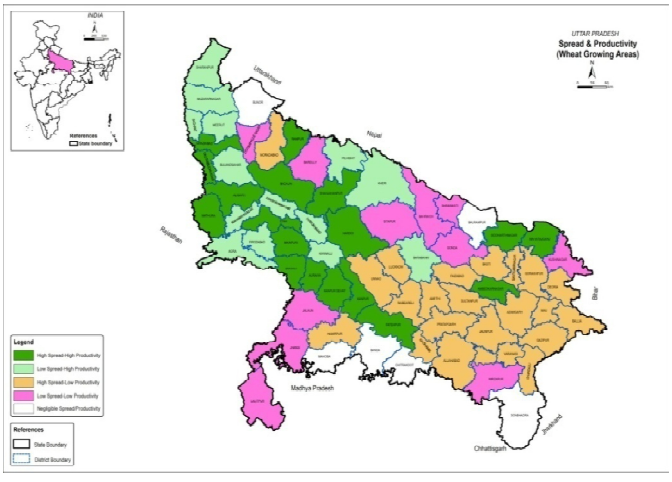


Fig. 2. Spread and productivity of wheat in Uttar Pradesh

and/or rotations; use quality seeds and planting materials of well-adapted varieties; implementation of conservation agriculture and the adoption of sustainable mechanization to maintain healthy soils and manage water efficiently.

The strategy of soil C management is to increase the amount of crop residues and biosolids to the soil surface through: (i) minimizing soil disturbance, (ii) providing continuous ground cover, (iii) strengthening nutrient recycling mechanisms, (iv) creating a positive nutrient balance, (v) enhancing biodiversity, and (vi) reducing losses of water and nutrients out of the ecosystem. There are three principal options to achieve these: (i) converting degraded lands to perennial vegetation, (ii) increasing net primary productivity (NPP) of agricultural ecosystems, and (iii) converting plow tillage to no-till farming. Following 10 steps has been identified for enhancing the carbon storage in UP.

10 Step Strategy

1. **Reduce carbon loss:** Carbon loss can be reduced through enforcement of regulations against burning of paddy straw or any other crop residues. Protect soil erosion and improve soil moisture through in-situ moisture conservation practices in specially in hilly regions of UP. Challenges to achieving large-scale carbon sequestration include imbalance soil-plant nutrients, inadequate farmer incentives and lack or improper management of organic matter in majority part of state.
2. **Promote carbon uptake:** Identify and promote best practices for storing carbon in ways suitable to local conditions, including through incorporating crop residues, cover crops, agroforestry, contour farming, terracing, nitrogen-fixing plants, and irrigation. We should identify the most suitable land use system which contributes soil carbon through its roots to a deeper layer and maintains for longer period of time. For example, application of balanced soil nutrients promotes micro-aggregation and accelerates SOC accumulation.
3. **Monitor, report and verify impacts:** Periodical changes in organic and inorganic carbon stocks must be monitored and evaluated in different bench mark spots of UP. An intervention with science-based harmonized protocols and standards should be identified for stopping the existing losses of organic carbon and new carbon building mechanisms.
4. **Application remote sensing & GIS technology:** Use high-tech opportunities such as GIS and remote sensing for faster, cheaper and more accurate monitoring of soil carbon changes in different management units of UP.
5. **Comparative assessment of strategies:** There are number of technologies published in literature and claiming that carbon stock can be improved. Reassessment of these technologies is essential for identification of what works in local conditions by using models and a network of field sites. This can be proved as a path for recuperating soil carbon stocks to mitigate climate change and boost soil fertility.
6. **Restoration of wetlands:** Wetlands comprised the largest pool of stored SOC. Therefore, SOC dynamics in wetlands can strongly impact the global C cycle. Conversion of wetlands into agricultural ecosystems have drastically disturbed the biogeochemical cycles. Cultivation of peatlands/wetlands harvesting must be strongly discouraged. Peatland management is also being linked to the Kyoto Protocol.
7. **Target non-arable land for SOC restoration:** Restoration mechanism of SOC in non-arable lands should be identify. For example, aggressive action to protect degraded forest, pasture lands, road side plantation etc.

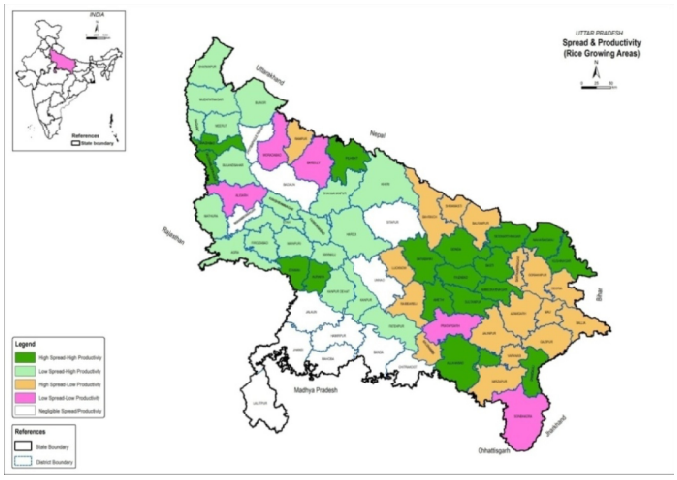


Fig. 3. Spread and productivity of rice in Uttar Pradesh

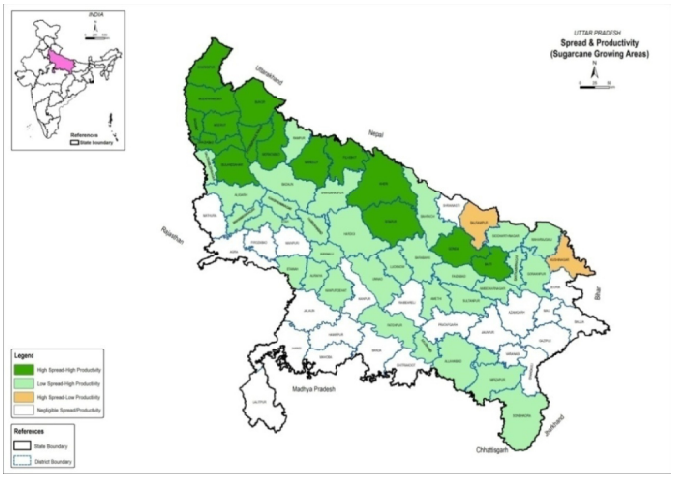


Fig. 4. Spread and productivity of sugarcane in Uttar Pradesh

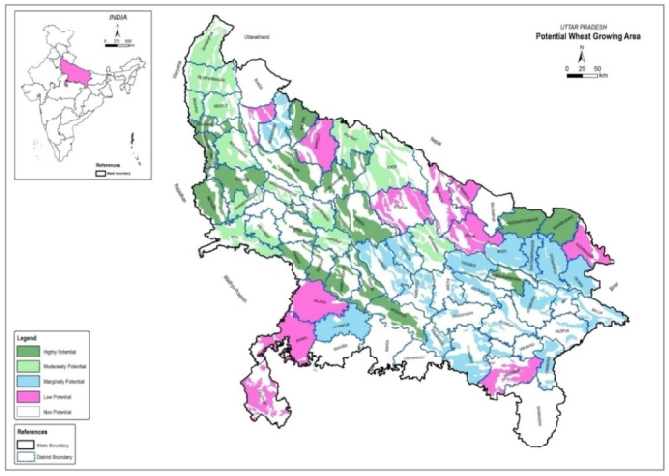


Fig. 5. Potential wheat growing area of Uttar Pradesh

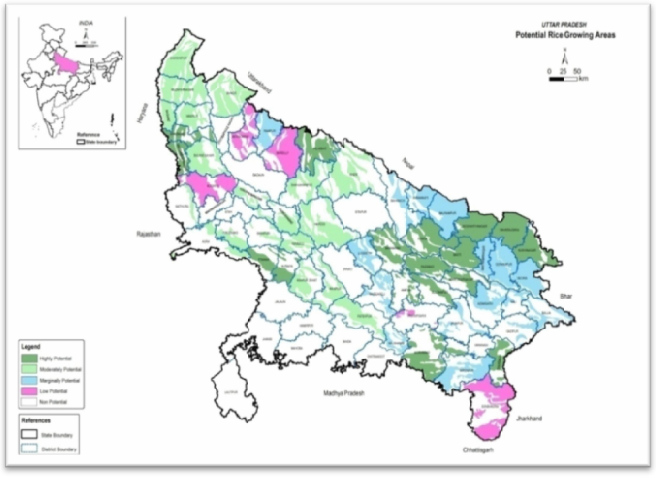


Fig. 6. Potential rice growing area of Uttar Pradesh

8. **Involve local communities and institutions:** Agro-ecological region wise distribution of different communities and institution of national and state importance should be identified to collect data and create an open online platform for sharing ideas.
9. **Coordinate policies:** Integrate soil carbon with national and global soil organic carbon map, policy makers.
10. **Provide support:** Ensure technical assistance, incentives to farmers, monitoring systems, and carbon taxes to promote widespread implementation.

Conclusions

Organic matter is being lost from our cropland mainly through plowing, which makes soil more likely to erode. Adding organic matter to farmland is good for soil quality and crop yields, both short-term and long-term. Continuous no-till is an efficient way of doing this. Cover crops and manure also help raise organic carbon levels. Management strategies include following of proper land use and farming systems, effective soil management practices and proper utilization of plant and animal wastes.

Table 1. On-site and off-site benefits of soil organic carbon

On-site benefit	Off-site benefit
1. Improvement in soil quality • Increase in available water capacity • Increase in aggregation • Increase in nutrient use efficiency	• Reduction in erosion 1. Decrease in sedimentation 2. Reduction in non-point source pollution 3. Improvement in water quality 4. Benefits to agriculture 5. Decrease in economic losses caused by flooding
2. Improvements in soil tilth 3. Decrease in cost of seedbed preparation	
4. Increase in crop yields 5. Sustainable use of soil and water	• Soil carbon sequestration • Decline in net CO_2 emission • Improvement in air quality

High temperature during summer season in semi-arid region of Uttar Pradesh has been reported to increase the rate of organic matter decomposition. Further, the diurnal variation in temperature resulted soil surface heating/cooling that causes increased wind velocity and more pronounced rate of soil erosion. Under such adverse climatic conditions, afforestation of the hills and hilly terrain, addition of FYM, green manuring and gypsum in sodic soils and appropriate land use combinations like agri-pastoral, agri-horticultural, agri-silviculture, horti-pastoral, horti-silvicultural and silvi-pastoral systems in waste lands would help in sequestering the desired quantity of soil organic carbon.

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HIGH NUTRIENT USE EFFICIENT ZINC AND SULPHUR FERTILIZER TECHNOLOGY FOR BALANCE CROP NUTRITION PROGRAM ON SUSTAINABLE AGRICULTURE

Ram Ratan Sharma*

Sulphur (S) and zinc (Zn) deficiency in soils are common nutrient problems throughout the world, both with respect to crop productivity and human nutrition. As per WHO estimation, around 800,000 people die annually due to zinc deficiency, among which 450,000 of these being children under the age of five years (Prasad, 2006). Sulphur plays vital role in plant functions and structure as it is a constituent of essential amino acids (cysteine, methionine, and cystine) involved in chlorophyll production and is thus required for protein synthesis. The nitrogen metabolism in plant is greatly influenced by sulphur. At inadequate uptake of sulphur, synthesis of proteins and oils is suppressed, and consequently, the absorbed nitrate that is accumulated as non-protein elements may result not only in loss of yield, but also may impair the quality of crop produce. The various results reveal that nitrogen and sulphur is required by crop plant in around 7:1 ratio for efficient utilization of nitrogen by plant. Application of sulphur is inevitable, particularly when nitrogen application is raised for higher production. Sulphur deficiency affects human nutrition by causing a reduction in cysteine and methionine content in the crop produce.

Zinc is essential micronutrient for the growth in animals, human beings and plants. It is vital for the crop nutrition as it is required in various enzymatic reactions, metabolic processes, and oxidation-reduction reactions. In addition, Zn is also essential for many enzymes that regulate the early growth stages, and is vital for fruit, seed and root system development; photosynthesis; formation of plant growth regulators; and crop stress protection. Zinc deficiency not only retards growth and yield of plants, but it also has effects on human beings.

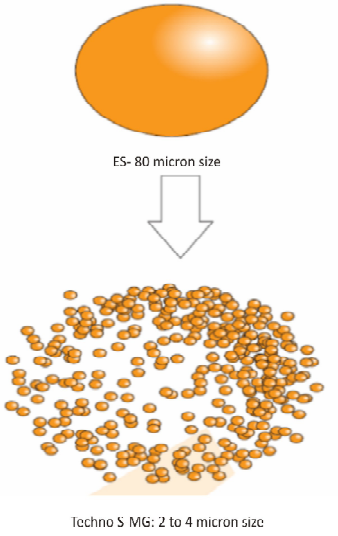
Sulphur (S) is the fourth most important nutrient element for plants after nitrogen (N), potassium (K), and phosphorus (P) in terms of amounts required by crops. Sulphur deficiency has become more prevalent in the last decades due to a decrease in incidental inputs through atmospheric deposition and an increase in crop S removals. Zinc deficiency is wide-spread and most common in calcareous and sandy soils. Availability of Zn to plants declines as soil pH increases. Therefore, S and Zn-containing fertilizers are need of time to large agricultural areas to increase crop yields and food quality. For sulphur fertilization, gypsum, ammonium sulfate and elemental S (ES) are the most common sources while Zn is provided mainly as zinc sulphate or zinc oxide. Sulfate-based fertilizers are prone to leaching below the root zone due water solubility in nature. Although ES is unavailable for plant uptake, it is oxidized in the soil to its plant available form SO_4.The oxidation of ES in soils occurs quickly if finely divided ES particles is mixed through soil. However, finely divided ES tends to have a high production cost and can pose a fire or explosion hazard during handling. Furthermore, applying fine ES particles to soil is impractical using current farmer fertilizer application practices.

The amount of sulphur and zinc based fertilizer to be applied in soil to meet the S and Zn requirement of plants is determined by its nutrient use efficiency (NUE). Most of the sulphur based fertilizer has NUE is in range from 8 to 12% while zinc based fertilizer has NUE in range from 2 to 5 % only (Soumitra Das *et al*., 2019), which indicates that most of the S and Zn nutrient part, from applied fertilizer, is not available to the crop plant and gets wastage.

*GM-Product Development, Sulphur Mills Ltd, Mumbai

To address the big concern about limited nutrient use efficiency of S and Zn based soil fertilizers, Sulphur Mills Ltd has developed a novel and patented water dispersible granule platform technology to improve the use efficiency of S and Zn and introduced "**Fertis/Techno S-MG**" (Sulphur 90% micro-granule) and recently "**Techno Z -MG**" (Sulphur 70% + Zinc 15% micro-granule) fertilizer in global market which requires significantly very low application dose due to its high nutrient use efficiency.

Technological Features in Techno Z –MGand benefits

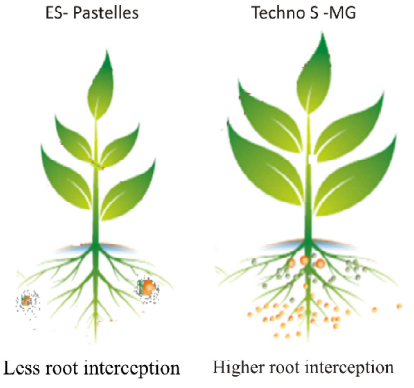


The Techno Z-MG is unique combination of micronized elemental sulphur and zinc oxide with an ultra micron particle size of S and Zn which is in ranged from 2 to 4 micron blended in balanced way to meet both S and Zn requirement of plant and formulated in water dispersible micro granule form of fertilizer by using the SML's platform technology which offers unique benefits in various ways

A) High Nutrient uptake by crop plant: This is directly correlated to Nutrient Use Efficiency (NUE) of fertilizer where in plant uptake more S and Zn from Techno Z-MG due to three key technological attributes of the products as described below

- **Ultra micron S and Zn particle size**: Techno Z- MG has ultra micron S and Zn particle size and due to this the oxidation of ES and ZnO in soils begins quickly when mixed in soil that results in early availability of S and Zn nutrients to the plants (with in 24hrs to 48 hrs) in comparison of bigger S and Zn particles size. Ultra micron particle of S and Zn will also have more surface area resulted in more particles available for microbes for faster oxidation.

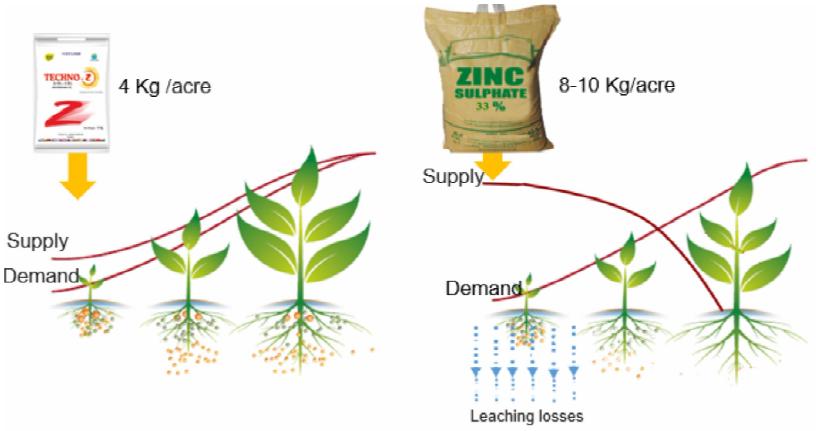
- **Water dispersible Micro granule formulation:** Water dispersibility is very much desired property of any water insoluble fertilizer nutrient for uptake by plants. Most of the water insoluble fertilizer is available in granuler/pastells form and they are available to plant if these granules are applied or placed at plant root zone. These granules gets diffused over a period of time in a limited soil column and covers less surface areas in soil therefore few plant roots comes in contact, which is called as less root interception, with diffused nutrient granules that results in less uptake of the nutrient by plant and hence less nutrient use efficiency (NUE) of these fertilizer granules. If these granules are applied by broadcasting then sparsely distributed granules will have very limited root interception therefore NUE further reduces.



Techno S-MG is a water dispersible micro granule (0.1 to 0.5mm) fertilizer which contain S and Zinc nutrients. On application of Techno S-MG in or on soil by any means or methods of application, its gets dispersed with water quickly and reaches root zone of the plant along with water and more S and Zinc nutrient particles comes in contact with plant roots therefore more root interception takes places and plant uptakes more S and Zn nutrients and hence high nutrient

use efficiency of these nutrients.

- **ORT Technology:** Zinc oxide is not readily available to plants when applied in soil. The co-micro granulating ZnO with ES fertilizers helps in acidification by oxidation of elemental sulphur (ES) which can solubilize ZnO and providing slow release of both sulphur (S) and zinc (Zn) in soil.



Generally 1 mole ES supplies enough protons to dissolve 1 mole of ZnO as per following reaction.

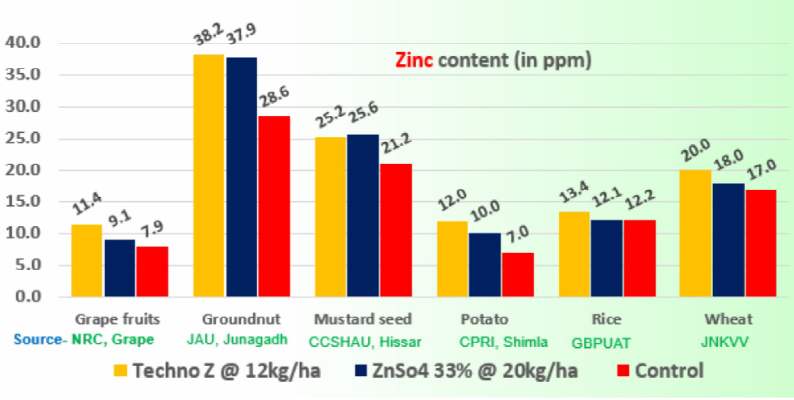
$S^0 + ZnO + 3/2\ O_2 \rightarrow ZnSO_4$

Hence, there is very less leaching losses of both S and Zinc from Techno Z-MG and both the nutrients are available to plant for longer time.

B) Gives flexibility in applications: Techno Z-MG fertilizer, due to its water dispersible micro-granule, provides flexibility for various application methods such as, fertilization by drip irrigation or overhead sprinkler irrigation, ground spray, soil injection, side dressing/drenching, side placement, coating on Urea and Ammonium sulphate for broad casting. As the Techno Z-MG has ultra micron S and Zn particle size and oxidation begin within 24 to 48 hrs into available sulphate and zinc ion, therefore its give further flexibility to apply from basal application to vegetative growth stage of the plant depending on its deficiency in the plant and soil.

C) High Zn& S fortification in harvest: Techno Z-MG gives benefit to plant by its higher S and Zn nutrient uptake resulted in higher S and Zn fortification into harvest.

Higher Zn and S fortification in plant produce through application of Techno Z –MG fertilizer, is attributed by its ultra-micron S and Zn particle size, more surface area coverage and higher root interception, slow release

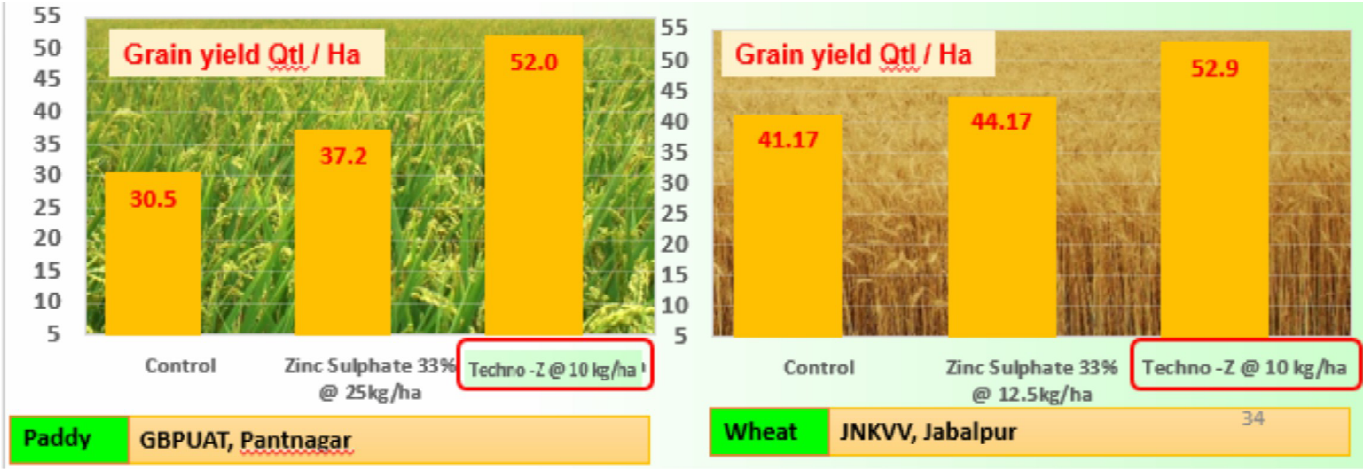


property and long duration availability of both sulphur (S) and zinc (Zn) to plant due to gradual oxidation, and preventing leaching or run off losses of S and Zn nutrients by water.

Co-micro granulation of Zinc with S also helps in more uptake of Zn by plant root due to solubilizing of Zn by acidifying of elemental sulphur under high pH soil conditions.

D) Fit in balance fertilization programme: Techno Z- MG is a co-micro granulated S and Zn fertilizer in a balance proportion of both nutrients required by plants. Application of S with Zn, not only supports for more Zinc uptake by plant but also supports for other nutrient uptake by plants particularly for N, Fe, Mn, Cu and Mg due to acidification by ES in soil. Further, $ZnSO_4$ has the compatibility issue while blending with other fertilizer particularly with P and Ca. Therefore, Techno Z-MG fits well in balance plant nutrition or fertilization programe.

E) High return of Investment : Techno Z-MG not only increase plant yield but also increase the harvest quality by higher Zn and S fortification in graineven after application of low doses in field and therefore its ensures high return of investment (ROI) to the farmers.



In over all plant fertilization programe, Techno Z-MG is a new generation ORT technology based low dose S and Zn fertilizer and its deliverable benefits can be concluded as below.

Untreated **Techno Z (Zinc 14% + S 69%)**

- Increased nutrient use efficiency (NUE) fertilizer and hence reduction of nutrient losses in environment
- Developed in Water dispersible micro granule form of fertilizer which give flexibility for various application methods in field
- Based on Patented ORT technology which meets S and Zn nutrient requirement of plant for longer time during crop cycle by single base fertilization
- Suitable for blending with all other nutrient fertilizer while application in field
- Increasing crop yield and nutrient fortification of harvest at lower nutrient application rates
- Higher cost benefit ratio to the farmers

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INTEGRATED FARMING SYSTEM: APPROACH FOR SUSTAINABLE MANAGEMENT OF NATURAL RESOURCES

D.K. Sharma*

The second half of 20th century, characterized by Green Revolution in many African, Asian and Latin American countries, witnessed a remarkable growth in food production but still a large population in many developing and under-developed countries did not have access to sufficient food (Godfray *et al*., 2010). Substantial increase in food production and a multitude of environmental problems co-evolved during this period characterized by the heavy and indiscriminate use of agro-chemicals in rice and wheat crops (Sinha, 1997). Despite impressive gains in food output, Green Revolution was thus seen to lack concerns for social equity and environmental sustainability (Conway and Barbie, 1988) and thus required a paradigm shift in means and ways of agricultural development with emphasis on socially just and environment-friendly approaches of food production and distribution (Sinha, 1997).

Agricultural Scenario of India

Indian agriculture contributes to 8 per cent in the global agricultural gross domestic product to support 18 per cent of world population on only 2.3 percent of world's geographical area. Agriculture continues to be the mainstay of Indian economy by providing livelihood to 54.6 per cent population; contributing 17.4 per cent of the gross value addition, 12 per cent of total exports with a growth rate of 4.1 per cent in agricultural production during 2016-17. The agricultural sector grew at the growth of around 4 per cent per year during 2004-05 to 2014-15 and the growth was quite impressive as compared to 2.2 per cent per annum during the previous decade.

In the past, increase in food production was mainly achieved by bringing additional lands into intensive cultivation through the use of improved seeds, heavy input use and liberal irrigation. In changing scenario, this approach does not seem feasible as land and fresh water are not only becoming scarce due to stiff completion from housing and industrial sectors, but diverse form of land degradation such as soil erosion, desertification, soil salinization and unsustainable cropping practices are turning many productive lands into barren patches (Godfray *et al*., 2010). The current alarming rate of natural resource degradation, spanning about 25 percent of the earth's soil and water resources and biodiversity, could adversely affect the food security of a burgeoning world population in the changing global scenario (FAO, 2011).

Changing Scenario

Indian agriculture is facing second generation problems comprising shrinking and degradation of natural resources, declining average size of land holding, multi-nutrient deficiencies, soil fatigue due to intensive cultivation, yield plateau in most of the crops, continuous decrease in the input use efficiencies, low total factor productivity, declining water table and a virtual halt in further expansion of the irrigated area have posed major challenge to maintain sustainable production levels without endangering the environment. Climate change is now reality and challenging the farmer's ability to adopt adaptation measures that are warranted.

It is manifesting as increase in mean temperature, changing pattern of monsoon (floods, droughts, more dry spells, high intensity rains in short time, etc.), shortening of winter period (terminal heat stress),

*Former Director, ICAR- Central Soil Salinity Research Institute, Karnal, Haryana- 132001

change in pest dynamics, increased heat waves, shifting of cropping zones, etc. Annual mean temperature for the country as a whole has risen by 0.560 C during 1901-2009 (Attri and Tyagi, 2010). It is estimated that crop production loss in India by 2100 AD could be 10-40 per cent despite the beneficial effects of increased CO_2 on crop growth. The agro-ecosystem has become more vulnerable to climate change and availability of resources especially the water has considerably reduced. The per capita availability of water will decline to 1140 m^3 by 2050 from 1820 m^3 in 2001. The ground water table in the most productive Punjab, Haryana and western Uttar Pradesh states is depleting by around 0.5 meter per year.

Efficient utilization of natural resources

It is high time to develop and promote region-specific IFS models for variable resource base of farmers. The concept of Integrated Crop Management (ICM) has great significance and relevance than the individual approach of soil, water, nutrient, crop, pest and energy management. It combines all good agricultural practices like integrated nutrient management (INM), conservation agriculture (CA), integrated weed management (IWM), integrated water management (IWM), integrated pest management (IPM), integrated disease management (IDM), integrated energy management (IEM), integrated post-harvest management, etc. In current scenario, the deteriorated soil-water-plant continuum and climate change is direly indicating the urgent need to follow ICM principles in the agrarian sector especially in vulnerable areas. ICM is particularly beneficial for small and marginal farmers because it aims to minimize dependence on purchased inputs, while utilizing on-farm resources. This has the potential to enhance the productivity of crops without commensurate increase in cost, thus increases farm profitability substantially. There is need to shape-up our research and development curriculum with redesigned ICM practices to address the emerging matrix of agricultural problems in holistic manner and to tackle production-, resource- and climate vulnerability- issues of farm sector while integrating soil, water, nutrient, crop, pest and energy management practices for improving system productivity and profitability

Benefits in terms of production and profit improvement over existing systems

Integrated farming system (IFS) promotes multi-disciplinary whole-farm approach which represents multiple crops and multiple enterprises in a single farm to achieve sustainable farming. It optimizes various farm components and farm resources and their integration for multi-enterprise farming systems in a given set of agro-ecological regime for enhanced soil health, resource use efficiencies, factor productivity, profitability and regular employment to farmers. IFS is an economically and environmentally sound diversified production system which has great potential in doubling farmers' income with careful planning and scientific intervention under Indian context. Integration of horticultural crops, dairy, fishery, goatry, poultry, duckery and piggery with existing farming systems enhance income manifold (200 to 450% or more). Recycling and intermittent use of products and by-products within the system could save cost to the extent of 45 per cent and even more. Besides diversification of crops and enterprises, there is need to introduce Agroforestry options to give resilience to the production system, varietal cafeteria approach, increased seed replacement rate and pesticide rotation shall be followed because it enhances resistance in all type of pests resulting higher rate application of pesticides or no effect of costly inputs in managing pests, etc. To harness the benefits of agricultural diversification, there is a need to link it with market, contract farming system, strengthen the Govt. /registered 12 agency procurement network to procure all the diversified produce at MSP/ reasonable price at village level to eliminate middle man and strengthen the value addition and processing industry with access to farmers.

Keeping in view the specific requirements of small and marginal farmers in post-reclamation phase, an integrated multi-enterprise model consisting of diverse components (field and horticultural crops, fishery, cattle, poultry and beekeeping) has been developed for 2 ha area for ensuring sustainable resource

use efficiency, high and regular incomes and employment generation. This model substantially reduces the production costs by synergistic recycling of resources among different components. Similar models are also being standardized for waterlogged sodic soils in Uttar Pradesh, highly saline black soils in Gujarat and coastal saline soils of West Bengal (Sharma and Chaudhari, 2012; Singh, 2009).

Multi enterprise farm pond based system for coastal degraded lands has been developed. Harvesting of rainfall and surface runoff from surrounding areas are the major objectives of farm pond with the aim of recycling the water for crops, animals during dry season. In the process, multi enterprise farm pond based production system can be developed to ensure multiple uses of water and income from components. Due to the factors of soil salinity and back waters in coastal areas especially in the forthcoming scenario of climate change having the influence of sea level rise, the farm ponds in coastal/degraded lands are expected to have either fresh or brackish water. In brackish water based farming system, apart from saline tolerant lines of rice up to an extend of 6 dS/m of electrical conductivity, ducks can serve as an important component as no mortality was observed when introduced gradually to saline water of different concentrations up to 15 ppt. The body weight recorded at different week intervals do not pronounce much difference in different concentration of salinity for a period of one, two and three week's interval. Additional return of 4000/- from 600 m^2 pond can be obtained from the duck component within four months through sale of eggs for ensuring rotational livelihood of farmers especially in the disadvantaged areas having coastal salinity as a constraint. Saline tolerant fodders can also be grown on the bunds of farm pond to support livestock production (cattle & goat). Brackish water prawn can be reared in the ponds. After testing the water quality in the pond, water can be utilized for irrigation during dry period (Ambast *et al*., 2011). Economics of various land shaping models at CSSRI, RRS, Canning town (W.B) were calculated and farm pond model emerged as the most profitable with highest B: C ratio of 2.41 followed by deep furrow (DF) and paddy cum fish (PCF). All the land shaping models have been generating higher net returns over the control plot

Long term experiment conducted at Karnal revealed that the highest system productivity in terms of rice equivalent yield (REY) was recorded with rice-wheat-moongbean cropping system (12.2 t ha^{-1}) followed by rice-wheat (11.1 t ha^{-1}) and maize-wheat-moongbean (7.0 t ha^{-1}). The average net income from crop and subsidiary components together was Rs. 348595/-, out of which Rs. 72020/- came from crop (including fodder), Rs. 35880/- from vegetables and fruits and Rs. 195650/- from subsidiary components from an area of 2.0 ha, which was substantially higher than conventional rice-wheat cropping system (Rs. 302250/-). Among all the systems, fruits and fisheries production were found more remunerative with a B: C ratio of more than 4, whereas, vegetable production system generated lowest B: C ratio (1.9) due to involvement of higher input cost and labour in this system.

The economy of the integrated farming system at village Kashrawan in Raibareli district of Uttar Pradesh was evaluated in terms of cost benefit analysis of the individual cropping systems. The B: C ratio of the various components under study varied from 1.70 in fruit based system to 2.63 fish farming system. The whole system B: C ratio comes to 2.21.

Conclusion

It can be concluded that diversification of existing farming systems with change in crop (s), cropping systems, addition and improvement of livestock components, inclusion of horticulture, primary and secondary processing, boundary plantations are essential to improve the on-farm income of small holders in India. This also paves way for meeting the household demand of balanced food, improved recycling of nutrients and water besides increasing the on farm employment for family. Diversification of existing farming systems clearly demonstrated the advantages. It has been observed that productivity gain of 2

to 3 times and increase in net return of 3 to 5 times is possible with improved systems. Further, resource saving of 40 to 50% can also be ensured besides enhancing the income of household to the level of at least Rs. 400 to 500/day. Additional employment generation of 70 to 80% is also possible. Improved diversified systems also ensure household nutritional security. Under extreme weather events also farm households having multiple components are better resilient than the single commodity based production system.

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POTENTIAL UTILIZATION OF FRUIT AND VEGETABLE WASTES FOR VALUE ADDED PRODUCTS

Neelima Garg*

India has become one of the largest producers of fruits and vegetables in the world producing approximately 30 million tonnes of fruits and 60 million tonnes of vegetables annually. But, due to their nature and composition and tropical and subtropical climatic conditions of our country, huge post harvest loses occur in the range of 25-40 %. This spoilage occurs at the time of harvesting, handling, transportation, storage, marketing and processing resulting in waste. In economic terms these loses may work out to be more than Rs. 5000 crores. Processing of fruits produces two types of waste:

- Solid waste of peel/skin, seeds, stones etc
- Liquid waste of juice and wash-waters.

In some fruits the discarded portion can be very high (mango 30-50%, banana 20%, pineapple 40-50% and orange 30-50%). These wastes are rich in organic constituents like, cellulose, starch pectin vitamins, minerals etc and posed serious health hazard problems due to high biological oxygen demand (BOD).

One way of managing the situation is to reduce the losses and the other is to utilize the available material for the production of value added products. The utilization of waste will not only economizes the cost of finished products but also reduce the pollution level. The waste could be used for the production of fertilizers, fuel and value added products through processing, extraction, hydrolysis or fermentation and as animal feed.

Status of work done abroad

Fermented edible products

A number of beverages such as cider, beer, wine and brandy, and vinegar can be obtained from the fermentation of fruit wastes. Apple pomace has been utilized for the production of cider. Best quality of cider can be made by carbonating it. Good quality apple cider and brandy can also be produced by fermenting milled apple pulp. The possibility of making brandy from dried culled and surplus apples, grapes, oranges and other fruits have also been explored. Vinegar can also be prepared from fruit wastes. The fruit waste is initially subjected to alcoholic fermentation by acetic acid fermentation by *Acetobacter* bacteria, which produce acetic acid. Vinegar production by fermenting waste from pineapple juice has been reported. Vinegar production by fermenting orange peel juice has also been attempted successfully. Apple pomace extract can also be mixed with molasses in the ratio of 2:1 for producing vinegar.

Candied peel

Peel from citrus fruits (orange, lemon, grapefruit) can be candied for use either in baked goods or as a snack food. In addition, shreds of peel are used in marmalades and the process to make these is similar to candying.

*Principal Scientist and Head, Division of Post Harvest Management, ICAR-CISH, Lucknow, Email: neelimagargg@gmail.com

Single Cell Proteins

Single cell proteins can be produced from dried and pectin extracted apple pomace by using Trichoderma viride and Aspergillus niger. The grape waste and pressed apple pulp have also been employed as a substrate for *Aspergillus niger* to generate crude protein and cellulose. Pineapple waste for single cell protein production has also been utilized. The waste from brewery and distilleries can also be used for the production of single cell proteins. Potato peels supplemented with ammonium chloride have also been used for the production of protein by using a non-toxic fungi *Pleurotus ostreatus*. Similarly, waste from orange, sugarcane and grape processing industry have also been utilized for the production of single cell protein.

Animal Feed

The waste obtained from processing of fruits and vegetables is rich in fibre, which includes cellulose, hemi-cellulose, lignin and silica with poor quality of protein. Fermented potato waste has been successfully tried as animal feed. Apple pomace after fermentation with different species yeast, followed by drying, makes the feed enriched with proteins, vitamins, minerals and fats and which can be used for feeding animals. Waste from wineries, breweries and distilleries can be used for feeding livestock. Animal feed can also be obtained from grape pomace after fermentation. Dry brewer's grains after addition of molasses become a very good cattle feed.

Alcohol

The waste from fruits and vegetable processing industries being polysaccharides (cellulose, hemi-cellulose and lignin) can be subjected to solid state fermentation for the production of ethanol, which has several uses. It can be used as a liquid fuel supplement and as a solvent in many industries. Process for production of ethanol from apple has been developed. Pear and cherry waste have also been utilized for production of ethanol. Orange peel after enzymatic hydrolysis was found suitable for the production of ethanol by use of *Saccharomyces cerevisiae*.

Biogas Production

Bio-mass consisting of agricultural, forest, crop residues, solid and liquid wastes from industries, sewage and sludge can be utilized for production of biogas through microbial technology. Similarly, the waste from fruit and vegetable processing industries has been used for production of biogas. Biogas is produced by anaerobic digestion of fruit and vegetable wastes. Methanotropic bacteria like *Methanobacterium* and *Methanococus spp*. can utilize CO_2 from waste materials to produce methane. During this process, the complex polymers are first hydrolyzed into simple substances by acid forming bacteria and finally these are digested anaerobically by methanotropic bacteria and methane gas is liberated.

Organic acids

These acids are produced through aerobic fermentation of sugars. Since they are produced in large amounts they could easily be extracted and purified from the fermented medium. Grape pomace when used as a source of fermentation, approximately 10% of citric acid could be produced. Important organic acids produced by fermentation are citric, acetic and lactic acids which could be used in many processing factories like confectionary, synthetic beverages, alcoholic beverages.

Enzymes

World trade in enzyme production is about 500 million US Dollars of which about 160 million US

Dollars worth are consumed by food and detergent industry. Pectinases are widely used for beverage and juice clarification. The total market for enzymes in India is about 20 crores with a predicted growth rate of 20-30% annually. Except papain, which is produced in plenty, for majority of enzymes used by food processing industry, India is dependent on imports. Enzymes from microbial sources are preferred compared to plant or animal sources because enzyme production from former is relatively cheap and controllable. The enzyme production cost can further be reduced if negative value or cheap value substrates such as fruit processing industry waste are used. This will also help in solving fruit industry waste problem to some extent and will reduce the pollution problem. A wide variety of fruit processing wastes such as apple or grape pomace, banana skin, orange peel etc. have been used for production of various enzymes such as cellulases, amylases, and pectinases. Lot of research work has been conducted on pectinase production from apple pomace, lemon peel, orange finisher pulp etc. Use of apple pomace, cranberry pomace and strawberry pomace for pectinase production has been reported. Polygalacturonase yield after 40 days of fermentation were 29.4, 20.1 and 4.0 Enzyme unit/g of strawberry, apple and grape pomace, respectively. A lipase with a unique specificity for unsaturated fatty acids was produced by *Geotrichum candidum* grown on sauerkraut brine. This enzyme is of industrial interest for the production of specialty chemicals from fats and oils. Â-glucosidase was produced by *Aspergillus niger* grown on apple pomace.

Waste utilization by chemical extraction

Some of the value added products like fibre, starch, pectin, oil, flavour and wax may be extracted from solid fruit wastes like peel, pomace etc. These materials have many uses in cosmetic, food and pharmaceutical industries.

Fibre

It has been reported that processing waste such as peel, pomace etc generally contain up to 30% of fibre. It may be obtained by treating the waste with alkali followed by boiling with hydrogen peroxide in alcohol. The fibre is increased the nutritional value of confectionary products.

Starch

The starch content in the peel and pulp of most of the fruits and vegetables is very less (2-5% on dry wt. Basis). However, mango kernel contains up to 58% starch. The starch may be extracted from the powdered seeds or kernel by washing repeatedly with sulphur waster so that all the soluble materials may be washed away. The starch is then separated from the settled residue. It is used as the flour and also in the pharmaceutical industries for making many formulations.

Pectin

This is a gelling agent used in jams and some sweets found to a greater or lesser extent in most fruits. Commercially, pectin is extracted from citrus peel and apple pomace (the residue left after apple juice has been removed). Some other tropical fruits contain high levels of pectin, passion fruit being a notable example. The utilization of the 'shells' remaining after pulp removal offers possibilities for pectin extraction. Two different options for the combined recovery of pectin and phenolic compounds from mango peels, a byproduct of industrial mango processing, were developed. After extraction of dried mango peels with diluted sulfuric acid, the phenolic compounds were adsorbed using a styrene–divinylbenzene copolymerisate resin, and pectin was obtained from the effluent by precipitation with ethanol. Phenolic compounds were recovered from the resin with methanol and the eluate was lyophilized.

Oils

The stones of some fruits (eg. mango, apricot, peach) contain appreciable quantities of oil or fat, some of which have specialized markets for culinary or perfumery/toiletry applications. Palm kernel oil is well established as both cooking and industrial oil. In addition some seeds (eg. grape, papaya and passion fruit) contain oil which has a very specialized market. The main problems are to identify the import/export agents, who would buy such products, producing the oil in sufficient quantities for them, meeting their very stringent quality standards and finally, obtaining the equipment needed to produce the oils at low cost.

Mango waste utilization

Peel forms 12-16% of mango waste and is a very good source of some nutrients such as sugars, pectin, proteins and fibres. The extraction of pectin from mango peel and evaluation of its quality has been done. The quantity was reported to be about 13% on a dry weight basis. The quality of such pectin on a jelly grade basis was compared with that of pectin obtained from citrus waste. Good quality pectin could be used in the manufacture of jams, jellies, marmalades and various pharmaceutical products. There is a tremendous scope for the utilization of mango peel as a carbon source for fermentation. Mango peel has been used for the production of fungal protein, carboxymethyl cellulose and polygalacturonase by fungi. The peel and pulp portion left over after juice extraction can be utilized to manufacture juice, nectar etc. by pectic enzyme treatment. A good quality vinegar with 4.5-5.0% acetic acid characterized by mild mango flavour can be prepared from mango peels and stones. The kernel is obtained by breaking the hard seed coat of mango stone. Kernel is a good source of nutrients such as starch, fats and proteins. Kernel oil could be a substitute or a partial replacement for tallow and cocoa butter in the preparation of quality soups and confectionery products .It has been reported that kernel fat added at the rate of 1% in ghee prepared form buffalo milk acted as an antioxidant. Kernel oil or fats can be used for manufacturing soaps, particularly because of its high stearic acid content. According to Ayurvedic system, it is known to cure stomatitis and vat. The seed meal after removal of oil can be utilized as cattle feed. The carbohydrate value of kernel has been reported to be 69.22%. Therefore, kernel flour could be supplemented with wheat flour.

Guava

Guava has been identified as a good source of pectin and seed oil which enhances its commercial value. Peelings, seeds and cores are the waste obtained from guava processing. Moreover during the processing of guava into juice and jelly considerable amount of pomace is left after separating the clear extract. This left over pomace goes as waste which can be utilized for preparation of various products. Guava cheese is very familiar in the name of 'Halwa' which has a very good indigenous as well as foreign market potential. The peelings give cheese of good set and deep brown colour and possess satisfactory flavour. The cheese made from seeds is rather soft, sticky and dark brown in colour possessing good flavour. The cheese from pulp, seed has a soft texture and fairly good flavour. A good set jelly was obtained by adding one and half time water to the waste (core portion along with seeds) obtained during canning and pulp preparation from guava fruits, to get an extract. This extract was filtered and jelly prepared after addition of proper amount of sugar and acid. Guava seeds are usually discarded during processing of juice and pulp. The seeds contain about 5-13% oil, and guava seed oil is rich is essential fatty acids. Oleic (54%) and linoletic (29%) are major fatty acids found in guava seed oil. The oil could be used as salad oil. The dried and ground guava pomace and seeds after suitable fortification can be used as animal feed. Guava pomace after extraction of juice has been for preparation of jam, cheese and toffee and pomace powder for preparation of toffee and biscuits. These products were organoleptically

acceptable and stable for more than 3 months.The damaged and rotten guava fruits are crushed; juice was extracted and mixed with damaged banana juice which was subjected to fermentation after suitable fortification using selective organisms. Maximum biomass was obtained after 35 to 50 hours of fermentation depending on organism used. Fermentation efficiency and ethanol yield were maximum at pH4.7 and 5.0.

Grapes

There are a number of by-products of winery and juice industry from grapes. In the preparation of juice and wine, grape pomace (skin and seeds) and grape stems are obtained as waste products. The amount of tart rates present, in grapes varies from 0.8-1.2 percent. Tartrates may be separated as cream of tartar of calcium tartrates. The recovery of calcium tartrate from different grape waste ranged from 1.5 to 5.6%. Seed Oil can be extracted from grape seeds which can be used for various purposes. Grape seed oil is a semi-drying oil resembling soybean oil and can be used in paints. It can also be used as table oil after it has been refined by treatment with sodium carbonate or other alkaline material to remove free fatty acids. Seeds are ground and oil is extracted by an expeller. A yield of 10-15 percent is reported. Bangalore Blue seeds contain nearly 18 percent fat. The hulls from the decertification of grape seeds contain a large percentage of tannin which can be extracted by boiling with water and concentrated to heavy syrup. Yield of 10 percent of tannin can be obtained from the hulls. Such as product is suitable for the tanning of hides. The press cake obtained after extraction of grape seed oil is suitable for stock feed. It is desirable to mix it with bran or similar material to reduce the tannin and crude fibre content of the mixture at the time of feeding.

Waste water utilization

The liquid waste generated during processing results from washing of fruits, vegetables, bottles, corks, vessels, floors, etc. this effluent contains both soluble and suspended organic matters principally carbohydrates, proteins, lipids, cellulosic and hemicellulosic materials. In addition it also contains pesticide residues, detergents and sanitizing agents. Although chemical treatment of the effluent is possible but it is expensive so the biological treatment is in practice. Besides being cheap, useful by-products are obtained in the form of methane and nutrient rich fertilizers.

The organic waste waters are treated in lagoons or stabilization ponds. Anaerobic ponds are primarily used to treat strong organic waste waters and are devoid of oxygen as a result of the high organic loading applied. Facultative ponds operate at lower organic loading and dissolved oxygen persists in the water column owing to the presence of algae. Maturation ponds are aerobic lagoons used as a polishing stage after facultative ponds in the treatment of waste waters containing faecal material and their principal function is pathogen removal. Aerated lagoons are basically activated sludge units without sludge recycle and operate at low mixed liquor suspended solids levels and relatively long retention times. Aerated ponds are very shallow lagoons. Usually incorporating mechanical aeration and are designed to optimise the growth of algae.

Aerated lagoons

The designs of aerated lagoons can be based on completely mixed reactor theory for BOD removal. Aerators in a completely mixed aerated lagoon provide enough energy to maintain the solids in suspension. The aerobic treatment of the waste includes activated sludge process but it has many limitations. These type of lagoons, due to high inputs, have specific use.

Anaerobic ponds

The anaerobic treatment of the waste has proved to be ideally suited for treating food processing waste. Anaerobic ponds are varying cost effective for the removal of BOD when it is present in high concentration. Ambient temperature in hot climate conditions are conducive to the biochemical reactions which take place in the anaerobic ponds. Anaerobic digestion is brought about in to two steps by two distinctive types of microorganisms in the same reactor. In the first stage, complex organic compounds are degraded, hydrolysed and converted into organic acids by acid forming bacteria. Methanogenic bacteria then convert it in to methane and CO_2. The resulting sludge is well stabilized and could be disposed off as fertilizer. The anaerobic fermentation has many advantages like requirement of low energy, high loading, uniform quality and generation of biogas.

Conclusion

The waste from fruit and vegetable processing in real sense is not a waste as everything can be profitably recycled, bio converted and utilized in one or the other form as food, feed or fodder. However, most of the technologies for the waste utilization are developed at the laboratory scale, so these technologies needed to be standardized for commercial exploitation by the industry. Since the waste is a source of pollution, it has to be treated before discharging into the environment. The regulatory agencies can act as catalyst in developing different processes for the utilization and management of waste arising out of processing industries and industries engaged in food processing should invest a part of their investment on research and development for waste utilization and standardization of the various processes which are commercially viable. Thus, proper waste utilization will add to the wealth of the nation and will benefit all involved in the process.

PARKING CARBON IN SOILS FOR MITIGATING CLIMATE CHANGE

Vikas Sharma*

The carbon cycle is a continuous process, with carbon moving between atmosphere to plants to soils/oceans and back to the atmosphere, through various biochemical processes. In which unit of the cycle, the carbon stays the longest makes all the difference. Climate change has been directly linked with increasing carbon in the atmosphere, in the form of CO_2. The increase in atmospheric carbon has been attributed to the contributions from the terrestrial unit of the carbon cycle in the form of burning of fossil fuels, conversion of forest lands to other land uses and adoption of degenerative agricultural practices. One of the major mitigation solutions lies in capturing the atmospheric carbon and parking it in the soils. However, to make the soils a sink for the carbon requires a complete change in the traditional land-use practices and adoption of regenerative agricultural practices. Apart from the protection of existing forest cover, conservation agriculture and climate-smart agriculture has been proposed to achieve this objective.

Nearing *et al.* (2004) warned that climate change is occurring, both in terms of air temperature and precipitation. Among the potentially most important characteristics of expected climate change concerning agriculture, are changes in climate extremes, warming of high latitudes, a shift of monsoon rainfall areas toward the poles, and reduction in soil humidity (Dufkova and Toman, 2004). In light of sufficient evidence of changing climate and its adverse impact on agriculture, FAO of the United Nations calls for Climate-Smart Agriculture (CSA). They define it as an "approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support the development and ensure food security in a changing climate". CSA's has three main objectives (FAO, Climate-Smart Agriculture Sourcebook, 2013) are:

- Sustainably increasing agricultural productivity and incomes for enhancing food security
- Building resilience and adapting to climate change
- Reducing greenhouse gas (GHG) emissions

In short Climate-smart agriculture tends to cope up with food security and development through ensuring productivity, adaptability, and mitigation.

Carbon sequestration forms an important component of the mitigation strategy. These mitigation options can be divided into three broad categories of practices (Harvey *et al.*, 2014):

(1) Activities that increase carbon stocks above and below ground;

(2) Actions that reduce direct agricultural emissions (carbon dioxide, methane, nitrous oxides) anywhere in the lifecycle of agricultural production; and

(3) Actions that prevent the deforestation and degradation of high-carbon ecosystems to establish new agricultural areas.

Removing atmospheric carbon (C) and storing it in the terrestrial biosphere is one of the options, which have been proposed to compensate greenhouse gas emissions (Albrecht and Kandji, 2003) and minimize the risks of climate change. However, options for sustainability, adaption, and mitigation may

*Professor & Head, Division of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu-180009.

or may not be different from each other. These tend to overlap over each other. For instance, soil carbon sequestration is an important mitigation strategy and at the same time makes soil healthy and productive thereby promoting sustainability. Terrestrial C pools (soil and biota) are important components of the global carbon cycle.

The SOC pool, estimated at 2500 billion tons to 2-m depth (Batjes, 1999), has been considerably depleted by the conversion of natural to agricultural ecosystems and by several soil degradation processes such as erosion, salinization, and nutrient depletion/imbalance (Lal, 2011). The SOC pool in soils of most agroecosystems is below its capacity as determined by climatic, pedological and terrain characteristics (Lal, 2004). Processes that lead to depletion of the SOC pool are deforestation, biomass burning and soil erosion which creates a large C debt (Fargione *et al.,* 2008).A considerable part of the current atmospheric C pool comes from the terrestrial ecosystem of which soil is a major component (Lal *et al.*, 1997). Soil organic matter isa key component of any terrestrial ecosystem, and any variation in its abundance and composition has important effects on many of the processes that occur within the system (Batjes, 1997). The accumulation and turnover of soil organic matter (SOM) is a major factor in soil fertility and ecosystem functioning and determines whether soils act as sinks or sources of C in the global C cycle (Post and Kwon, 2000). Total soil C storage is about 2-3 times that stored in aboveground vegetation and is about two times more than the total atmospheric C (Wang *et al.*, 1999).

Carbon sequestration

Several definitions have been given for C sequestration, all referring to the accumulation of C in the terrestrial ecosystem. Soil Science Society of America defines carbon sequestration as "the storage of carbon in a stable solid form through direct and indirect fixation of atmospheric CO_2". Bernoux *et al.* (2006) provide a definition which takes into account all the fluxes of greenhouse gases (GHG), expressed in equivalent CO_2 or equivalent C-CO_2 exchanges, originating from different ecosystem pools. They state that "Soil carbon sequestration or Soil-plant carbon sequestration for a specific agro-ecosystem, in comparison with a reference, should be considered as the result for a given period and portion of space of the net balance of all GHG expressed in C-CO_2 equivalent or CO_2 equivalent". Since the C moves in and out of the atmosphere as a part of the C cycle, the idea is to retain the C in a soil-plant system for a longer time to enhance the terrestrial C storage in relation to atmospheric C levels.

Land use and soil carbon

Land use strongly influences soil properties and unsuitable practices lead to the degradation of soil and environmental quality (Papini *et al.,* 2011). Change in land use contributes C to the atmosphere in two principal ways (1) release of C in the biomass which is either burnt or decomposed and (2) release of soil organic carbon (SOC) following cultivation due to enhanced mineralization brought about by change in soil moisture and temperature regimes and low rate of return of biomass to the soil. Several studies demonstrate that changes in land use and management can strongly affect soil organic matter properties; conversion from forest to croplands, combined with conventional tillage and lack of biomass return to soil, is reported to reduce the degree of soil organic matter humification (Lal and Kimble, 1997; Yang *et al.,* 2004). Factors including vegetation coverage, the amount of litterfall and root impact, and disturbance or management regime can contribute to the significant variation of surface soil SOC across different land uses (Degryze *et al.,* 2004; Chen *et al.,* 2007). Agricultural lands and wastelands had up to 25 % lower SOC stocks than forest soils, indicating that deforestation or conversion of forest land to agricultural uses is contributing to losses of up to 12.4 Mg ha^{-1} SOC over time from the top half a meter layer of soil (Sharma *et al.,* 2014).

Permanent organic soil cover (Mulching) and Crop management

It refers to the use of crop residues and other litter (Natural) as well as synthetic material like polyethylene sheet etc., to cover up the soil. Mulching minimizes the effect of splash erosion to a considerable extent as it prevents raindrops from directly hitting the soil. It also slows down the runoff by creating surface hindrance promoting infiltration and moisture storage. Mulching dissipates the energy of falling raindrops, reduce surface sealing, increase infiltration and decrease runoff velocity (Kukal and Hadda, 1999). Mulches not only help in reducing soil erosion but also helps in conserving soil moisture and improving the yields in rainfed areas. Sharma and Arora (2012) reported from a field study that dry matter yield of both maize and wheat improved significantly in mulched plots over the un-mulched plots in the *kandi* region of Jammu. They have recommended the application of *Adhatoda vasica* (Brankad) @6 t ha^{-1}. Other plant materials as available under local conditions may also be utilized. Residue from preceding wheat crop may also be made use of depending upon the individual farmer's requirement. Mulch treatments reduced annual water runoff losses by 10 to 50% relative to the conventional tillage treatment depending on residue amounts, slope and year (Vashisht*et al.*, 2013). Soil carbon fractions tend to increase with the application of straw mulch overtime. Wang *et al.* (2018) observed that various soil carbon fractions such as SOC, particulate organic C, and microbial biomass C increased by 8 to 27 % over unmulched plots. They noted that benefits from straw mulch were better during the growing season rather than mulching during the fallow period, in terms of soil organic C sequestration. Enzymatic activity in soils has been identified as an indicator of the state of soil health, because of their usefulness in motoring long-term changes in soil health and quality (Frankenberger Jr and Dick, 1983). Important soil biochemical activities such as decomposition of organic matter and nutrient cycling are controlled by various enzymes. Incorporation of cover crops into rotations tends to increase the enzymatic activity in soil (Hamido and Kpomblekou-A, 2009).

Tillage (Minimal Disturbance) and residue retention

Mechanical soil disturbance and exposure to climatic elements are major factors that degrade soil structure, accelerate soil erosion and increase soil carbon loss. Ploughing and soil turnover lead to soil exposure, promoting conversion of soil C to CO_2 and subsequent loss to the atmosphere. An effective erosion-control strategy, therefore, lies in minimizing soil disturbance and keeping the soil surface covered. A system of seedbed preparation based on the concept of minimum soil disturbance and maintenance of crop residue mulch is called "conservation tillage". Conservation tillage can be defined as any practice that leaves at least 30 percent cover on the soil surface after planting. This includes No-till, Zonal tillage, and minimum tillage. Minimum and zero tillage are recommended for soils of the Indian Himalayan region due to reduced cost of cultivation, more retention of soil water, and physical protection of soil organic carbon (SOC) (Bhattacharyya *et al.*, 2009, 2012). Numerous reports have been published linking decreased land disturbance with increase organic carbon in soils. No-till (NT) had nearly 16 % higher total Soil organic carbon content compared with conventional tillage (CT). Labile pools of SOC were positively affected by conservation tillage practices. Plots under NT had higher macroaggregates and macroaggregate-associated SOC after 6 yr of study than CT–CT plots (Bhattacharyya *et al.*, 2012).CA results in more biotic diversity in the soil as a result of the mulch and less soil disturbance. Removal of crop residues from the fields is known to hasten soil organic carbon (SOC) decline especially when coupled with conventional tillage (Yang and Wander, 1999). Mann *et al.* (2002) reviewed several studies where additions of stover resulted in greater increases in SOC than if stover was removed.

Agro-forestry

Agroforestry systems are believed to increase or at least maintain the organic matter level of soils (Young, 1989) mainly through litterfall. Agro-forestry systems improve the aggregation of soil through

huge amounts of organic matter in the form of leaf biomass. Soils under forest land use have higher total organic carbon (Hussain *et al.*, 2019) which results in more stability of soil aggregates (Kukal *et al.*, 1993). The C harvesting potential of the trees and the biomass input (in terms of litterfall) to the soil thus is an important factor reducing the erodibility of soils, apart from sequestering carbon and the same can be utilized in agroforestry systems. The extent of improvement may be affected by the age of the trees and the soil type. The soils under agroforestry had 2.9–4.8 Mg ha^{-1} higher soil organic carbon than in sole crop (Gupta *et al.*, 2009).

Conclusions

There is ample evidence in that the conservation/ climate-resilient agricultural practicessuch as reduced tillage, crop cover and management significantly increase the soil organic carbon content. These practices can help sequester carbon in the soils and reduce a significant load of atmospheric carbon, which may reverse the impact on climate. Numerous combinations of CA practices that include reduction in tillage, whether it be minimum or zero, type of crop rotations, soil cover, etc. have been tried and found to be successful in C sequestration. Appropriate combinations based upon the eco-system need to be selected for a sustainable agricultural production system based upon their potential to increase the soil carbon. Long term parking of carbon in the soils not only provides a solution to climate change but will also help in making soils healthier and agriculture more sustainable.

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EXPLOITING NATURAL BIORESOURCE FOR EXPEDITING NATIONAL BIOETHANOL DEMAND

Pushpa Singh*

Agricultural crops and forests generate considerable amounts of leftover residues (leaves, stalk and roots), which is an expensive natural bio-resource. Globally, leftover residue production from agriculture and forests is pegged at 210 billion MT. These leftover residues (non-economical plant parts) are produced after harvest of wide range of crops cultivated across different agro-ecological regions of India. With the net cropped area of 195 Mha (about 43%) and forest cover of about 71.3 mha (21.6 % of total surface area), it is estimated that India generates around 850 MMt of crop residue annually (GOI, 2016) with wide regional variability (Fig. 1). The uneven distribution and use of crop residue depends on the crops grown, cropping intensity and productivity across the nation. The highest crop residue estimate was recorded for Uttar Pradesh (60 Mt). Other high crop residue producing regions were Punjab (51 Mt) and Maharashtra (46 Mt). Cereals, fibers, oilseeds, pulses and sugarcane contributed the majority of crop residue with production estimates of 372 Mt, 66 Mt, 40 Mt, 130 Mt and 185 Mt, respectively (Table 1). Among cereal crops, rice, wheat, maize and millets together contributed 70% of crop residue followed by fiber crop (13%). India thus is a huge reservoir of this natural bio-resource and generates nearly 234 million tonnes per year (about 30%) as surplus. As it varies with crops, the lignocellulosic Residue to Product ratio (RPR) varies accordingly (Table 1). The trend in crop residue generation in India shows uplift with a CAGR of 2.53% annually (Fig. 2). Of 850 MMt gross crop residue production on an annual basis, about 395 MMt is burnt each year, leading to not only loss of bio-resource but also a missed opportunity to improve a farmer's income.

Natural Bioresource for Bioethanol Production

Crop residue has great economic value as it is composed of mixture of C, H, O and N. Chemically; they are rich source of carbohydrates, primarily 5- and 6- carbon sugars stacked in between the lignin fibrils. As raw materials, these residues are an attractive potential for production of ethanol, heat and electricity, liquid and gaseous transportation fuel and biogas through combustion, pyrolysis, gasification, fermentation and anaerobic digestion. Their increasing demand as feedstock for energy and organic agriculture has indicated a competitive opportunity for crop residues. The residues alone generate 140 billion tons of biomass, which is equivalent to approximately 50 billion tons of oil. The state wise bioenergy potential from surplus residues has show significant variations (Fig. 3). The energy generated from these wastes can substantially displace fossil fuel, reduce emissions of greenhouse gases and provide renewable energy to about 1.6 billion people in developing countries, which still lack access to electricity. Findings have suggested that corn stover, rice and wheat straw, sorghum stalks and leaves, pineapple and banana leaves can be used for their conversion to ethanol. Efficient conversion of crop residues into ethanol will thus be the new engine for meeting out the national ethanol demand. Skilful exploitation of this natural resource shall go a long way in sustaining India's energy requirement.

Bioethanol Demand

India is the fourth largest energy as well as crude and petroleum products consumer in the world after United States, China and Japan (Fig. 4). The fossil fuel /oil consumption in India is expected to

*Principal Scientist, Indian Institute of Sugarcane Research, Lucknow-226002

Table 1. Area under different crops and their respective residue production (2010)

Crop	Gross cropped area (Mha)	Total Economic Production (Mt)	Total Residue Production (Mt)
Rice	46.1	118.8	213.9
Wheat	28.5	98.5	157.6
Jowar	5.3	6.1	12.2
Bajra	8.6	6.8	13.6
Maize	6.6	13.0	32.5
Other cereals	1.3	1.4	2.8
Red gram	3.6	2.7	11.2
Gram	7.7	7.0	13.5
Other pulses	12.5	5.9	17.1
Ground nut	9.3	12.2	28.1
Rape seed and Mustard	10.7	12.0	24.1
Other oil seeds	18.0	13.5	27.1
Cotton	10.1	15.9	55.7
Jute	0.6	6.5	10.5
Sugarcane	5.5	463.5	185.4
Coconut + Arecanut	2.8	-	28.2
Mulberry	0.3	-	3.3
Coffee +tea	0.8	1.0	3.9
Total	178.2		840.6

Source: Rabindranath *et al.* (2005)

reach more than 8 million barrels per day by 2035. Thus, development of alternative sources of energy from second generation biofuels assumes critical importance. Ethanol blending in petrol is an effective way of increasing domestic petrol availability. A report recently filed with the USDA Foreign Agricultural Service's Global Agricultural Information Network shows the average ethanol blend rate in India is reached a record 5.8 percent in 20, up from the record of 4.1 percent set in 2018. India currently aims to achieve an E10 blend by 2020 and E20 by 2030. According to the report, India's Ethanol Blending Program stipulates procurement of ethanol produced directly from B-heavy molasses, sugarcane juice, and damaged food grains. A surplus sugar season coupled with financial incentives to convert excess sugar into ethanol is expected to help the country's oil marketing companies (OMCs) procure more than 2.4 billion liters (634.01 million gallons) of ethanol in 2019. The report indicates it is unlikely the country's E20 goals will be reached by 2030 due to the general inability of the cane industry to supply India's fuel demand. India, has a target of blending 10 per cent ethanol with petrol by 2022 to cut dependence on imports. To achieve the target, approx. 313 crore litres of ethanol is required. According to the Union Ministry of Petroleum and Natural Gas, the current ethanol availability is only about 300 crore litres. Of this, about 130 crore litres goes into making of liquor, which is non-negotiable for states as liquor is a major revenue source for them. That leaves around 170 crore litres, out of which about 60 to 80 crore litres goes into making chemicals. That leaves only about 100 to 120 crore litres for blending, which obviously is in sufficient to achieve the blending targets. The National Bio-fuels Policy, 2018, has therefore sought to widen the range of feedstock for ethanol production from the present sugar-molasses to other waste such as agricultural cellulosic and ligno-cellulosic biomass and rural-urban garbage, in line with the "*waste-to-wealth*" concept. The permissible feedstocks includes the crop residues, sorghum, sugar-beet, cassava, decaying potatoes, damaged grain including maize, wheat, rice, and most importantly,

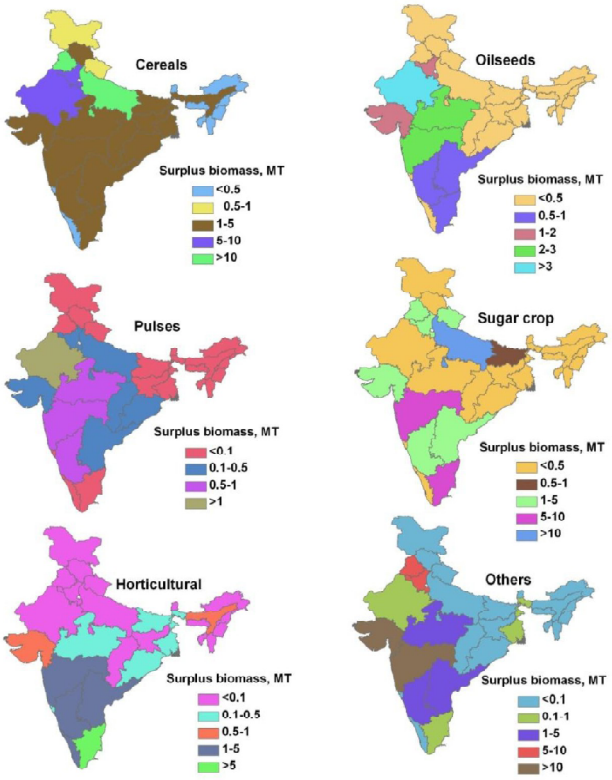

Fig.1. Surplus crop residue biomass potential in India (*Source:* Moonmoon *et al., 2014*)

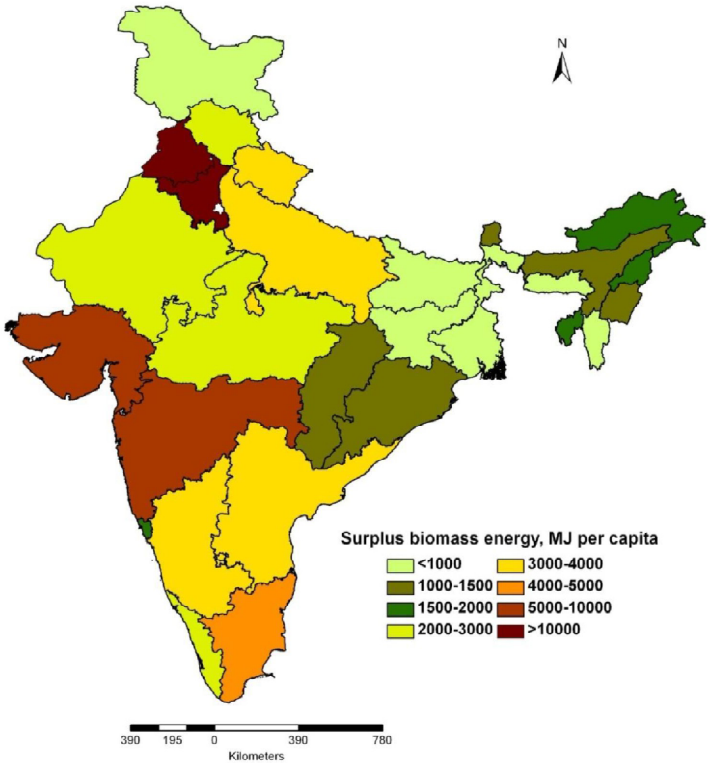

Fig. 3. State wise per capita crop residue bioenergy potential in India (*Source: Moonmoon et al., 2014*)

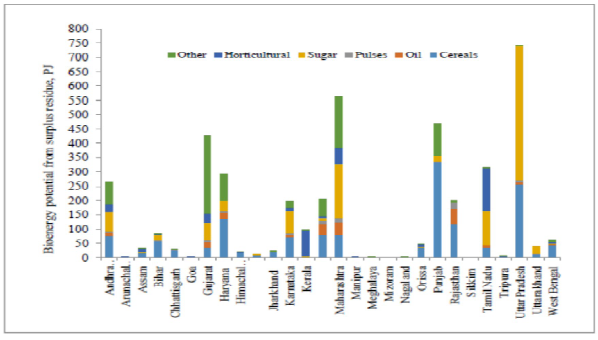

Fig. 2. State wise crop residue bioenergy potential in India (*Source*: Moonmoon *et al*., 2014)

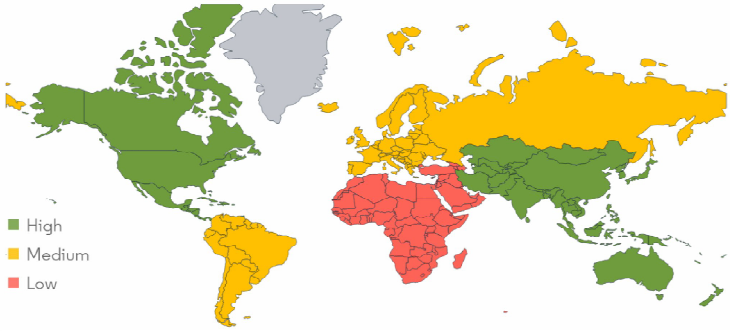

Fig. 4. Bioethanol Market - Growth Rate by Region 2020-2025 (Source: Mordor Intelligence, 2020)

crop residue such as wheat and rice stubble (Table 2). This shall allow the farmers to sell their surplus output to ethanol manufacturers, when prices slump.

Processing Routes for Exploiting Biomass Residues for Harnessing Bioethanol

Production of bioethanol from agricultural residues that con-tain lignocellulose is attractive and sustainable because ligno-cellulosic biomass is renewable and non-competitive with food crops (Table 3). Furthermore, the use of bioethanol obtained from lignocellulosic biomass is related to the considerable reduc-tion of greenhouse gas emission. Lignocellulosic biomass is almost equally distributed on the earth,

compared to the fossil resources, which provides security of supply by using domestic energy sources. . It can be obtained from differ-ent residues or directly harvested from forest and its price is usually lower than of sugar- or starch-containing feedstocks. The average lignocellulosic biomass contains 43 % cellu-lose, 27 % lignin, 20 % hemicellulose and 10 % other com-ponents. Compositional variety of lignocellulosic biomass could be an advantage (availability of more products than ob-tained in petroleum refineries, and a broader range of feed-stocks), but also a disadvantage (need for a large range of technologies. Such heterogeneous structure of lignocel-lulosic biomass requires more complex chemical processes than uniform and consistent raw materials needed in chem-ical industry. Furthermore, harvesting of lignocellulosic crops is usually not possible throughout the whole year, which makes it more difficult for biomass suppliers. Therefore, this problem has to be solved by biomass stabilization in order to be available for long-term storage, and to ensure continuous work of biorefinery throughout the year. The hydrolysis of lignocellulosic biomass to monomeric sugars is necessary before microorganisms can metabolize them. Acids, alkalines or enzymes usually perform this pro-cess.

Physicochemical, structural and compositional factors can considerably slow down this process. Therefore, alkaline pretreatment step is usually necessary to obtain conditions for an efficient enzymatic hydrolysis. In the pretreat-ment, reduction of polymerization degree and crystallinity index, disruption of the lignin-carbohydrate linkages, removal of lignin and hemicelluloses and increase of material porosity have to occur in order to insure the efficient enzymatic hydrolysis of lignocellulosic biomass. The choice of pretreatment depends on the nature of the raw ma-terial and the formation of byproducts during the selected pretreatment, and its choice has a large impact on all subse-quent stages in the bioethanol production. Harsh conditions used during pretreatments lead to the synthesis of toxic compounds, like furans (2-furaldehyde (fur-fural) and 5-hydroxymethylfurfural (HMF)), carboxylic acids (acetic, formic and levullinic acids) and phenolic compounds (aldehydes, ketones, *p*-coumaric and ferulic acids). Because these compounds are potential yeast inhibitors, following strategies (to reduce their impact on the bioprocess perfor-mance) were proposed: (*i*) removal of inhibitors by solvent extraction, ion exchange, overliming, usage of zeolites, or en-zymes (*ii*) use of yeast strains very tolerant to inhibitors, and (*iii*)

Table 2. Ethanol yield from crop residues and other feedstocks

Substrates / feedstocks	Cellulose content (%)	Hemicellulose content (%)	Lignin content (%)	Ethanol yield (L/ton of biomass)	References
Agricultural residues	30-45	20-30	10-20	235-450	Rezania *et al.* (2017)
Forest biomass and waste	20-30	35-50	20-30	220-285	Kraan (2013); Zabed *et al.* (2017)
Perennial grasses	25-40	25-50	10-40	160-460	Griffey *et al.* (2010)
Aquatic plants/ sea weeds	15-35	17-44	3.5-19	255	Saini *et al.* (2015)
Municipal solid waste	33-49	9-16	10-14	154	Saini *et al.* (2015)

Source: Behra and Ray (2018)

Table 3 Ethanol Availability for Blending

Year	**Total Ethanol Demand (Billion L)**		
	5%*	**10%**	**20%**
2020-21	4.3	6.3	10.2
2025-26	5.7	8.6	14.4
2030-31	7.5	11.9	20.5

*5%, 10% and 20% blending targets

selection of effective pretreatment that causes mini-mal sugar degradation and formation of inhibitors. Effective skills, policies, machinery and exploitation of the surplus residues for producing ethanol can help in expediting the national ethanol demand and meet out E10 and E20 blending targets.

Conclusion

Crop residues are of great economic value as feedstocks for fuel and industrial raw material. A large amount of it is not being economically exploited and is treated as waste. Imposing a ban on burning of crop residue may not be fruitful unless growers are enlightened with the negative effects of it on human, animal and soil health, crop biodiversity, the micro and macro-environment. The energy value of agri-residues is 6565 PJ and a tonne of crop residue has the potential of producing about 200-300 L of bioethanol (Table 2). Ethanol production from residues depends on efficiency of bioenergy system, the conversion process, quantity of commercially available residue and technologies, costs and policies. Their proper utilization and conversion in coming years can meet out the -ethanol blending targets. Exploiting natural resources for production of bioethanol can thus serve to be one of the most promising and environmentally friendly renewable sources of energy.

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STANDARDIZATION OF ON-FARM COMPOSTING OF MUNICIPAL SOLID WASTE FOR RESTORATION OF DEGRADED SODIC LANDS AND ENHANCING PRODUCTIVITY OF RICE-WHEAT CROPPING SYSTEM

Y. P. Singh*, Sanjay Arora and V. K. Mishra

To overcome the hazardous problems due to generation of municipal solid wastes, its use as a source of soil amendment to improve soil health and crop productivity of salt affected soils is of paramount importance. Vermicompost or Industrial processed municipal solid waste compost available in the markets is costly and beyond the reach of small and resource poor farmers therefore; present study was conducted to standardize cost effective on-farm composting process of municipal solid waste combined agricultural wastes. Seven treatment combinations with two decomposing agents like earthworms and microbes were used in the study. During the composting period, temperature varied between 24 to 27°C, moisture content ranged between 43.88 to 69.32%, pH increased from 6.97 to 7.48 while electrical conductivity decreased from 1.33 to 0.66 dSm^{-1}. Total N, P, K, Ca contents and microbial populations increased whereas, total carbon, C: N, C: P and C: K ratios decreased. The lowest C: N ratio (17.13) and highest microbial population was recorded in treatment T_7. The results of this study showed a significant improvement in soil physico-chemical and microbial properties of sodic soil and productivity of rice-wheat cropping system with application of reduced dose of gypsum followed by decomposed municipal solid waste.

Introduction

About 1.3 billion tons municipal solid waste (MSW) is generated per year in the world as byproducts of industrial, mining, municipal, agricultural and other processes and is expected to rise about 2.2 billion tons per year by 2025. According to the report of central pollution control board (CPCB), India produces 12.74 million tons MSW per day (CPCB, 2012). It is increasing with growing population, changing life styles, migration of people from rural areas to cities and rapidly growing up of tourism generating an enormous quantity of MSW every day. In India, it is generally produced from household kitchen, commercial complexes, industries and agriculture and dumped in open grounds or non-sanitary landfill. These landfill sites are an environmental hazard – emanating methane causing greenhouse effect, smell and dirt causing health problems, and leachate contaminating the ground water, etc. (Kansal, 2002). Uttar Pradesh, one of the largest states in India is producing about 5515 tons MSW per day (CPCB, 2012) and municipal solid waste management is one among the major challenges faced by the state government particularly in urban areas. Municipal solid waste compost (MSWC), having high organic matter content and represents a source of nutrients that can improve soil fertility and physical, chemical, biochemical and microbial characteristics of soil (*Walter et al., 2006)*. Most of the studies on use of municipal solid waste compost (MSWC) are confined to improve soil fertility and productivity of normal soils (Hanay *et al*., 2004). However, very few studies are conducted on use of MSWC for amelioration of salt affected soils. In India, about 6.73 million ha are salt affected which represents 2.1% of the geographical area of the country (Mandal *et al*., 2009).

*Principal Scientist & Head, ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow-226002, Email: ypsingh.agro@gmail.com

Out of these, 2.8 million ha are sodic in nature and primarily occurring in the Indo-Gangetic alluvial plains. Gypsum ($CaSO_4.2H_2O$) is the most commonly used as chemical amendment for reclamation of sodic soils. However, this approach fails to improve the physical and biological properties of salt affected soils suffering from low hydraulic conductivity caused by dispersion.

On-farm composting of MSW is an attractive proposition for turning organic waste materials into a farm resource. Therefore, the present study was conducted to standardize the methodology for on-farm composting of MSW combined with agriculture waste to get aesthetically acceptable and useful compost and to investigate its effectiveness for restoration of degraded sodic land and enhancing crop productivity.

Materials and Methods

Standardizing composting process

To standardize on-farm composting, study was conducted under aerobic conditions at ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow, India, during October 2014 to January 2015. Composting material including MSW and agricultural wastes was filled in 12 feet long, 4 feet wide and 4 feet high vermi beds in October 2014 and enriched with earthworm and microbial treatments. The chopped agricultural wastes of mustard straw, paddy straw, leaf litter of *Casuarina* and *Pongamia* were used as composting material. For rapid decomposition, three efficient degrading microbial cultures such as strains of *Aspergillus spp.*, *Trichoderma spp.* and *Bacillus spp.* and earth worm (*Eisenia foetida*) were used with seven treatments consisted of T_1: 100% MSW, T_2: 100% MSW + microbes, T_3: 50% MSW + 50% agricultural wastes + microbes, T_4: 100% MSW + earth worms, T_5: 50% MSW + 50% agricultural waste + earth worms, T_6: 100% MSW + earth worms + microbes, T_7: 50% MSW + 50% agricultural waste + earth worms + microbes. A uniform quantity of water was applied at alternate days in each bed and monitored the moisture content at regular interval. The composting material was turned at every 15 days interval. To monitor the changes in temperature, 60cm long metal probe thermometers were inserted in each bed up to 30cm depth.

Monitoring changes during composting

Changes in physical properties

Temperature from each treatment was recorded daily at 11.00 AM with a 60 cm long metal probe thermometer (Sharholy *et al.*, 2005) fixed in each bed. To monitor the changes in moisture content, sample were collected from 3 places in each bed from 30 cm depth, mixed together and make a composite sample and analyzed moisture content gravimetrically on fresh weight basis.

Changes in chemical properties

During composting, samples were collected from three places in each treatment bed at 30 days interval, mixed together and make a composite sample. Part of the sample was kept in refrigerator at 4^0C temperature for microbial study and the remaining sample was dried, grounded and sieved through 0.2 mm sieve for chemical analysis. The matured compost obtained after 120 days was analyzed for its bio-chemical and quality parameters. The methodology to analyze was same as followed for analyzing initial properties of MSW.

Changes in microbial properties

To analyze the microbial changes during composting, standard media such as nutrient agar for bacterial population and potato dextrose agar for fungal population were used. The serial dilution of 10^{-3} and 10^{-4} of the compost samples were prepared to isolate the microbes from the compost samples using

spread plate technique. Spread 1µl sample of both dilution on different medium and incubated at 30^0C for 48 hours. After incubation, the viable colonies were counted using colony counter (Dubey *et al*., 2006).

Performance of MSW compost on soil properties and crop productivity

Experimental details

Three times replicated field experiment consisted of three treatments (i) control i.e. neither gypsum nor compost was applied; (ii) gypsum alone @50% GR; and (iii) MSWC@10t ha^{-1} + gypsum @25% GR. was conducted at Shivri, experimental farm of ICAR-CSSRI Regional Research Station, Lucknow, Uttar Pradesh, India (26° 47′ 58′′ N, 80° 46′ 24" E) in 2014-2016. After completion of pre reclamation process, MSWC was applied @10t ha^{-1} and mixed uniformly in soil surface up to 15cm depth. Rice and wheat crops were grown in Kharif and Rabi seasons respectively and all the recommended agronomic practices were followed. Following the rice-wheat crops, soil samples were collected from surface soil (0-15cm) and analyzed for a number of physico-chemical and microbial properties described by Klute (1986). The initial properties of the experimental field are given in Table 1.

Table 1. Initial soil properties of experimental field

Soil properties	Values
pH (1:2)	9.80
EC (dS m^{-1})	1.47
ESP	78.30
OC (%)	0.13
Available N (kg ha^{-1})	68.72
Na (meq l^{-1})	11.70
K (meq l^{-1})	3.10
CO_3 (meq l^{-1})	6.00
HCO_3 (meq l^{-1})	22.00
Bulk density (g cm^{-3})	1.59
Cumulative infiltration rate (mm day^{-1})	2.10

Results and Discussion

Changes in physico-chemical characteristics during composting

Changes in temperature during composting are one of the imperative parameter which plays an important role in composting process (Khalil *et al*., 2011, Singh, *et al*., 2017). From the study it was observed that there was no significant difference in temperature between the treatments. The moisture content under different treatment was unstable throughout the composting process; it may be due to change in microbial population (Narkhede *et al*., 2010). The moisture content during the composting period varies from 33.31 to 69.32%.

The pH of waste materials used for composting was initially slightly acidic (6.80 – 6.97) and later it becomes slightly alkaline because of ammonia formation and at the end of composting it dropped close to neutral. It may be due to humus formation with its pH buffering ability. However, at maturity it reduced to 7.72 which seem neutral in reaction (Fig. 2). It may be due to stabilization of organic acids (Khalil *et al*., 2011, Singh *et al*., 2018a). Electrical conductivity (EC) is a major factor to determine the quality of compost as high salt concentration can inhibit the seed germination (Rawat *et al*., 2013). The results indicate that the EC decreased with increasing the time. At maturity, highest EC was recorded in

the treatment where MSW was enriched with both microbes and earthworms. The decline in EC may be because of more stable bond between ions and organic matter throughout composting (Moretti *et al*., 2015).

Total N, contents in MSWC at maturity increased in all the treatments. The highest total nitrogen at initial stage was found in treatment where MSW and agricultural wastes were mixed in equal amount and treated with decomposing microbes, however, at maturity, highest total nitrogen was estimated in the treatment where mixture of MSW and agricultural wastes were treated with both microbes and earthworms. It is imperative to report here that total nitrogen content at maturity exhibited increasing trends in all the treatments, this may be due to concentration effect caused by strong degradation of labile organic compounds (Bernal *et al*., 1998). Similar trend was observed in total P and total K content (Table 1).

The highest total carbon content at the maturity was recorded in treatment where MSW and agriculture wastes mixed in equal proportion and treated with earthworm. It decreased at maturity as compare to its initial values. This was due to the breakdown and transformation of complex organic compounds into simpler compounds and evolution of CO_2 and assimilation of carbon by microorganisms (Cabrera *et al*., 2005).

The lowest C: N ratio at initial stage of composting was found in treatment where only MSW was used and treated with earthworms (24.69) whereas, at maturity lowest C: N ratio (17.13) was observed in treatment where 50% MSW and 50% agricultural wastes were enriched with both earthworm and decomposing microbes.

Table 1. Changes in physico-chemical and biological properties of MSW compost during composting

Treatment	Stage	Total Nitrogen (%)	Total Phosphorus (%)	Total Potassium (%)	Total carbon (%)	C:N ratio	Microbial	
							Bacterial population (Cfu/g)	Fungal population (Cfu/g)
T_1	Initial	0.41	0.21	0.49	14.14	34.50	$48x10^4$	$45 x10^4$
	120DOC	0.43	0.41	0.56	11.14	25.89	$26 x10^4$	$33 x10^4$
T_2	Initial	0.47	0.33	0.50	12.69	27.82	$54x10^4$	$60 x10^4$
	120DOC	0.51	0.40	0.56	11.31	22.17	$44 x10^4$	$26 x10^4$
T_3	Initial	0.50	0.26	0.50	13.00	26.44	$79x10^4$	$60 x10^4$
	120DOC	0.58	0.40	058	13.63	23.50	$56 x10^4$	$36 x10^4$
T_4	Initial	0.46	0.26	0.53	11.35	24.69	$73x10^4$	$42 x10^4$
	120DOC	0.51	0.41	0.65	11.19	21.94	$60 x10^4$	$28 x10^4$
T_5	Initial	0.50	0.31	0.56	13.92	27.84	$69x10^4$	$52 x10^4$
	120DOC	0.56	0.40	0.76	13.69	24.44	$54 x10^4$	$23 x10^4$
T_6	Initial	0.43	0.25	0.54	12.02	27.97	$79x10^4$	$41 x10^4$
	120DOC	0.65	0.40	0.67	12.03	18.51	$68 x10^4$	$18 x10^4$
T_7	Initial	0.42	0.31	0.61	14.60	34.78	$98x10^4$	$79 x10^4$
	120DOC	0.79	0.39	0.74	13.54	17.13	$75 x10^4$	$48 x10^4$

Changes in biological characteristics during composting

During the composting process significant changes occurred in microbial populations. The experimental analysis showed that the bacterial and fungal count (Cfu/g) was higher at initial stage and it gets reduced at the maturity. The highest population of bacteria and fungus at 30 and 120 days of composting (DOC) was recorded in treatment T_7, whereas, the lowest in the treatment T_1 and T_6, respectively. This is because of the depletion of nutrients which is an indicator for completion of composting process. Pathak *et al*. (2012), also recorded a decreasing trend in microbial population with the composting age.

Based on the above study it was concluded that treatment T_7 produced high quality compost in terms of its nutrient status and C: N ratio. This compost was used in the highly sodic soils (pH 9.8, EC 1.47dS m^{-1}) in combination with gypsum to monitor its effect on restoration of degraded sodic soils and crop productivity.

Soil improvement and crop productivity

From the data given in Table 2, it was observed that there was significant improvement in these parameters over the control when reduced dose of gypsum (25% GR) and MSWC @10t ha^{-1} were applied. Furthermore, analysis shows that the application of gypsum alone has successfully reduced the soil pH, EC, and ESP values to 9.15, 0.72 and 32.0, respectively (Singh, 2018b, and 2018c). Nevertheless, application of gypsum alone, while being successful in improving soil properties significantly, does not have much effect on soil physical and microbial properties. In our study, we have observed significant improvement in soil organic carbon content due to application of gypsum followed by cultivation of rice-wheat crops.

Grain yield of rice and wheat was significantly higher with application of gypsum @50% GR and

Table 2. Improvement of soil properties and crop productivity after application of alone and combined use of gypsum, and MSW compost

Soil properties	Control	After application of gypsum @50GR	After application of reduced dose of gypsum and MSWC@10t/ha	LSD $_{0.05}$
pH (1:2)	9.55±0.13	9.15±0.05	8.84±0.06	0.26
EC (dS m^{-1})	1.47±0.23	0.72±0.16	0.35±0.12	0.32
ESP	58.00±0.70	32.00±0.36	24.00±0.33	2.31
OC (%)	0.13±0.01	0.29±0.01	0.32±0.01	0.03
Av.N (kg ha^{-1})	68.72±1.23	98.61±0.70	132.40±1.42	11.32
Na (meq l^{-1})	11.70±0.21	10.41±0.33	9.91±0.42	0.65
K (meq l^{-1})	3.10±0.06	0.11±0.04	0.12±0.02	0.06
CO_3 (meq l^{-1})	6.00±0.03	2.33±0.01	2.33±0.01	0.24
HCO_3 (meq l^{-1})	22.00±0.42	2.66±0.23	6.25±0.11	1.12
Bulk density (g cm^{-3})	1.59±0.01	1.57±0.01	1.41±0.03	NS
Cumulative infiltration rate (mm day^{-1})	4.10±0.32	11.15±0.21	17.21±0.24	2.14
Microbial biomass carbon (µg g^{-1})	16.25±1.30	28.00±3.70	58.20±2.41	4.32
Grain yield of rice (t ha^{-1})	2.77±0.12	4.54±0.12	4.72±0.07	0.29
Grain yield of wheat (t ha^{-1})	0.24±0.02	2.07±0.21	2.42±0.12	0.26

The values are the means of three replications, and the numbers in parenthesis are the standard deviations.

application of gypsum followed by MSWC over the control (Singh *et al*., 2019). Rice grain yield increased to 70.4% when gypsum and MSWC was applied whereas, it was only 64.0% higher with gypsum alone as compared to control. Similarly, wheat grain yield with application of gypsum alone and gypsum followed by MSWC increased to 762.5 and 908.33%, respectively over control where no amendment was applied.

Conclusion

The study concluded that the combined use of municipal solid wastes and agricultural wastes for composting is an alternate option to waste management. The municipal solid waste compost prepared through on-farm composting using 50% municipal solid waste + 50% agricultural waste enriched with earth worms (*Eisenia foetida*) and degrading microbial strains produced nutrient rich, cost effective quality compost. With the application of MSW compost with reduced dose of gypsum saved about 50% gypsum without significant loss in grain yield. Nevertheless, when the sodic soil treated with combined use of gypsum and MSW compost, physico-chemical and microbial properties of sodic soils were improved resulting improving soil fertility and crop productivity. With the use of municipal solid waste compost as source of organic manure may reduce dependency on inorganic fertilizers and promote organic farming.

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RECENT ADVANCES IN COLE CROPS BREEDING

M.L. Meena*, B.C. Shivran, Rajmani Singh and Ruchika Abha

Cole crops: a group of vegetables crops has originated from a common parent, the wild cabbage or cole wart; Brassica oleraceavar.sylvestris. These are known as Cole crops. This group of vegetables includes nine crops of which cauliflower, cabbage, knol-khol, brussels sprouts, broccoli and kale are important ones. Heterosis, genetic resources, male-sterility, self-incompatibility (SI) and cytoplasmic male sterility (CMS) were used to verify their suitability for breeding ofcole crops. The possibility of reproduction of SI and CMS lines in isolation cages using insect pollinators were proved. The studies conducted on these vegetables in Japan and the USA has revealed certain protective properties against bowl cancer. The cole crops are a rich source vitamin A and C.They also contain minerals phosphorous, potassium, calcium, sodium and iron. Thus, there is an urgent need to improve its production and productivity per unit area, time and energy. Therefore, it is essential to identify the best parents which can exploited to bring about genetic improvement for various characters in cole crops.

Introduction

Cole crop are among the most widely grown vegetables in the world. Cole group of vegetables includes nine crops of which cauliflower cabbage knol-khol, Brussels sprouts, kale, collards, Marrow stem kale, kitchen kale, and thousand head kale and broccoli are important ones. All the crops of this group originated from wild cabbage/ colewort (*Brassica oleracea* L. var. *Sylvestris).* It is a group highly differentiated plants. In general cole crops are used against gouts, diarrhoea, colic trouble, stomach trouble, deafness and headache. The cabbage juice is said to be remedy against poisonous mushrooms and used as gargle to remove hoarseness of throat. The leaves are used to cover wounds and ulcers and also recommended against hang-over. The studies conducted on these vegetables in Japan and USA have revealed certain protective properties against bowl cancer [1-2]. The cole crops area a rich source of vitamin A and C. They also contain minerals phosphorous, potassium, calcium, sodium and iron. The cole crops are the most sustainable and affordable sources of micronutrients including minerals, dietary fibres as well as health related phyto-chemicals such as antioxidants, vitamins, andhydrolytic products of some of glucosinolates. These phyto-chemicals play an important role in reducing the risk of developing several types of cancers, cardiovascular and many other chronic diseases. With the evolution of heat tolerant Indian/tropical cauliflower and standardization of indigenous seed production techniques mainly for cabbage and late cauliflower, under available temperate conditions they have spread fast to both tropical and subtropical areas after second Word WAR. In India cabbage and cauliflower is the most important crop whereas broccoli is gaining

Fig: A general view of groups of Cole crops

*Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow-226 025, E-mail: drmeena1977@gmail.com

popularity. The knol-khol is grown in the limited pockets and brussels sprouts only near cosmopolitan cities or tourist places.

Breeding objectives in Cole vegetables

- The main criteria for crop improvement are to attend grower and consumer. For grower breeder is to attend higher production and production and productivity, disease resistance & abiotic stress, uniformity and continuity of cropping. For consumer it is appearance, commercial quality, shelf life, taste and nutritional value.
- The most important objective of breeding is crop uniformity, since a uniform *Brassica* vegetable field makes grading much easier and reduces harvest time.
- The final objective is to have a once over harvested field of uniform quality. High uniformity has been almost impossible to be achieving with open-pollinated varieties owing of the cross- pollination habit of *Brassica*.
- Self incompatible but cross-compatible inbreds to be used development hybrids in Cole crops.
- Doubled haploid technique may be used to develop SI and inbred lines to be taken as parents.

  Disease resistance is another very important breeding objective. Sources of resistance to important diseases e.g. black rot, downy mildew, *sclerotinia rot*, curd and inflorescence blight.
- Appearance, including colour and shape, is an important extrinsic trait and the only major breeding objective that is addressed to the consumers. Nutritional quality is slowly gaining popularity with *Brassica* vegetable breeders as this aspect will give marketing advantage in the future.

Heterosis breeding

With the realization of the potential of hybrid cultivars especially in vegetable crops, the area under cabbage hybrids in India has increased to 30%, however it is more than 98%in developed countries. Most of the hybrid seed of cole crops marketed under different brand name in India is imported by private seed companies by spending huge amount of foreign exchange. In some cases it is not systematically evaluated and results into failure of crop. Moreover, large number of diseases or insect pests or their strain(s) not present in India found way through import and become limiting factor in the cultivation of these crops in near future.

Hybrid vigour in cabbage was observed as early as 1935 but heterosis breeding came into worldwide notice with the release of first hybrid "Nagaoka No. 1" developed using self-incompatible line in 1950. In India hybrid vigour for vegetable and seed yield contributing traits has been reported by number of researchers using indigenous germplasm including SI and CMS lines. In cauliflower hybrid vigour was first reported by [3-4] and subsequently by [5] and [6] and many other Indian researchers in Snowball/ European (summer) group. Appreciable amount of heterosis has been reported by various researchers in all the three maturity groups of Indian cauliflower. In general it has been observed that percent heterosis was highest in early followed by mid and late maturity group for most of the economic traits. Many workers also used self-incompatible of male sterile lines to study heterosis in Indian cauliflower. Hybrid vigour has also been reported in sprouting broccoli and Brussels sprouts under Indian conditions.

Uniformity for curd/head size, shape, maturity and longer staying ability in field after maturity, wider adaptability, resistance/tolerance against important diseases and insect- pests besides yield and quality parameters are some of the important characteristics which need to be taken into consideration while going for development of hybrids in cole crops. Exploitation of heterosis in any crop can be achieved

through development of hybrid combinations. The viability of commercial hybrid mainly depends upon its economic hybrid seed production. The genetic mechanisms of self-incompatibility (SI) and male sterility are predominantly present in majority of cole and have been successfully exploited in development of hybrids.

Genetics resource

The germplasm collection of all the Cole crops is being maintained at IARI, regional station katrain, IARI, New Delhi, IIVR, Varanasi, Pantnagar, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni (Solan), R.A.U. Sabour and P. A. U. Ludhiana diverse and large number of germplasm in Indian cauliflower under different maturity groups including SI and male sterile lines is available. These genotypes will prove more suitable to develop indigenous hybrids.

Self-incompatibility (SI)

In cabbage self-incompatibility has been exploited since the development of first commercial hybrid in 1950. In India the Katrain station is actively engaged in development of SI lines. Lines having high level of self-incompatibility namely 83-1, 83-2, 83-5, Sel-5, Sel-8, AC-208 and C-6 are being used in the development of hybrids. KGMR-1 is the first indigenously developed public sector F_1 hybrid of cabbage by the IARI, R. S. Katrain utilizing SI line. Green Emperor, Quisto, BSS-32, BSS-50, Nath-401, Nath-501 and Sri Ganesh Gol are some of the private sector hybrids identified for release under the AICRP (VC). Other cabbage hybrids which are popular among the farmers include Green Express, Regalia, Stone, OS Cross, KK Cross, Green Cornet, GS-403, Bahar, Kranti, Varun *etc.* In cauliflower, [2-3] has reported high level of self-incompatibility in biennial winter and autumn types and low in European summer types. Earlier studies conducted at IARI, New Delhi brought a strong nature of self-incompatibility in Indian cauliflower. It was found that SI level was higher in genotypes of early maturity group-I than group II and III. The studies brought in the development of 7 SI line namely aa (327), aa (395), xx (EPK),cc-12,cc-13, cc-14, cc-15 in early and 6 SI lines CC (12 C)VV(351), dd(PAU), bb (PKUG) 443-5 and 443-7 in mid maturity group. Snowball types have very low level of SI and a line 87 (162587) has been isolated at Katrain recently. Indian cauliflower has been exploited to a greater extent for hybrid development since it has higher level of SI and wider genetic diversity. At IARI, New Delhi two hybrids, Pusa Hybrid-2 and Pusa Kartik Sankar (DCH-54) have been developed by using self-incompatibility. The former is the first indigenous hybrid developed by public sector and belongs to mid maturity group and latter to early maturity group. Pusa Early Synthetic and Pusa Synthetic are the other cultivars identified through AICRP (VC) and are popular among the farmers. SYCFH-202, Summer King, PCUCH-3 and SYCFM-203, are some of private sector hybrids identified for release under the AICRP (VC) in Indian cauliflower. The most commonly grown varieties of knolkhol are White Vienna, Purple Vienna and King of North, Amongst them White Vienna and Early White Vienna are most popular varieties. In case of brussels sprouts the IARI, Regional station, Katrain has recommended Hilds ideal which is suitable for cultivation in India. Recent interest in its growing has led to the testing of exotic introductions by few universities (IARI, Y.S.P.Uni. H&F and PAU) and best ones are being picked up for growing under our conditions , Sel-603,Sel-663 and Sel-636 are promising lines being proposed for release by IARI. Recently IARI has released a variety, Pusa Broccoli KS-1, which is doing well in the hills. At Katrain station lines with high level of SI have been isolated in kale and knolkhol and being exploited in the development of hybrid combinations. A high level of self-incompatibility was reported in four Indian green sprouting broccoli genotypes at HPKV, Palampur, These were found suitable for developing indigenous hybrids in sprouting broccoli.

Male sterility

Male sterility is characterised by the absence of functional pollen grains (male gametes) but female

gametes are normal and functional. Male sterility in cole crops was reported by [7]. It may be genetic male sterility or cytoplasmic male sterility.

Genetic male sterility

Spontaneous occurring genetic male sterility has been reported and found stable and governed by single recessive gene ms in many cole crops. In India it was reported by [8-9] in Indian cauliflower. This could not be exploited in developing commercial hybrids mainly due to the non-availability of morphological marker associated with male sterility and thermos- sensitive nature of its expression.

Cytoplasmic male sterility

Cytoplasmic male sterility was transferred into cabbage from radish by [10-11] by successful introduction of cabbage nucleus into the cytoplasm of male sterile radish reported by Ogura through reported back crosses. Cytoplasmic male sterility was found best alternative to overcome the practical problems faced in using self-incompatibility and or genetic male sterility to produce hybrid seed. Nuclear genome of some cole crops was transferred into cytoplasm of *Brassica nigra,* Ogura *Raphanussativus,* tour *Brassica tournefortii* (Anand cytoplasm-through *B.rapa*) and *Eruca sativa* via *B. compestris* through back cross substitution followed by protoplast fusion wherever required to develop CMS lines in cabbage, cauliflower, broccoli and Brussels sprouts.

The Ogura cytoplasm was commonly used to develop CMS line for breeding commercial hybrids in cabbage, cauliflower, Brussels sprouts and broccoli. The work to transfer Ogura CMS system via kale into different members of cole crops was initiated at the IARI, R. S. Katrain and subsequently at Delhi during early nineties. But this system was associated with many defects such as chlorosis at low temperatures, poorly developed nectarines and delayed maturity and as such could not be utilized in the development of commercial hybrids. Later on these defects were corrected by protoplast fusion and in 1999-2000 at IARI New Delhi improved Ogura CMS system form broccoli was transferred into Indian cauliflower and annual tropical cabbage. Three CMS lines, MS01, MS04, MS05 in early, two lines MS09 and MS 10 in mid maturity group of cauliflower and two lines CMS-3 and CMS-K-3 in annual cabbage were developed and being used in breeding of commercial hybrids. At Katrain in Snowball cauliflower three CMS lines Sera K-1, Sera K-25 and Call B-1 were developed and being used in heterosis breeding. Two CMS based hybrid KTH-1 and KTH-2 are being evaluated under AICRP (VC) AVT-II trials in cabbage also 10 CMS lines having improved Ogura CMS are in advanced stage of their development. The CMS system has been transferred in the background of promising indigenous germplasm in all the crops including broccoli, knolkhol, brussels sprouts besides cabbage and cauliflower.

Future Prospects

1. Stress should be given to breed hybrids/varieties having good quality, more nutritive, high yielding with desirable glucosinolates level and tolerance to high temperature.
2. Improvement for higher productivity and abiotic stress resistance.
3. Curd colour and shape; antioxidant and bioactive compounds:
    a) Carotenoids especially Beta-carotene
    b) Anthocyanins
    c) Green and violet tissues are rich in antioxidants such as ascorbic acid and glucosinolates (hydrolyzed by myriosina enzyme in isothiocynates). Glucoraphanin is present in broccoli.

d) Coloured products are good for functional food as they are rich in nutritional function and prevent diseases

4. Identification and Exploration new areas for seed production.
5. Development of indigenous CMS lines.
6. Diversification of CMS lines.
7. The government of India should encourage the promotion of indigenous hybrids by promoting technological up-gradation for sustaining the hybrid technology in the country.

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SUGARCANE CULTIVATION: PERSPECTIVES FOR CONSERVING NATURAL RESOURCES AND DOUBLING FARMERS' INCOME

T. K. Srivastava*

Sugarcane farming in India dates back to pre-Vedic period and the crop and its cultivation is integral to Indian culture and agriculture. As for economic importance the crop is not only the sole source of raw material for sugar production it also provides bio-fuel for automobiles, bagasse for animal feed & paper industry, molasses for alcohol and several other products used for manufacturing of chemicals, soil amendments and electricity generation. Further, sugarcane plays very important role for rural economy in the country being a cash crop. However, the remuneration earned by a grower and profitability of sugarcane cultivation varies with the cultivation practices, climatic conditions, soil fertility, government policies with regard to the crop and the efficiency of sugar mills. As an instrument of agrarian reforms and economic emancipation, sugarcane is perhaps second to none. This is so, because it is a labour intensive crop and provides livelihood to millions through an organized industry that carries with it in rural India. The crop provides means for sustenance to about 6.0 million farmers, their dependents and 0.5 million factory workers.

Sugarcane cultivation is the bedrock of rural economy of India particularly in the 10 major sugarcane growing states of the country. A look on advancements in sugarcane research, its production scenario and the transfer of technology to the stake holders during the recent past evinces encouraging trends and new challenges. On the research front, development of new high yielding high sugar varieties supported with suitable production and protection technologies made sugar sector viable on one hand and left ample scope for diversification on the other. During the year 2018-19 as per the latest estimates sugar production is expected to touch an all-time high level of 33-35 million tonnes with record sugarcane production of more than 400 million tonnes produced from 5.43 million hectares. The largest sugarcane and sugar producing state of Uttar Pradesh is estimated to produce about 12 mt of sugar by crushing comparatively less cane with a high recovery of 11.48%. The increased production and sugar recovery have provided scope for diverting sugarcane juice, B-heavy molasses and other substrates for the production of ethanol to be used as bio-fuel for automobiles.

Sugar requirement is expected to grow substantially in the coming years due to the population growth and increased per capita consumption mainly owing to changing consumer preferences towards variety of dishes, value added food products, high demand for beverages and other upmarket products. Sugarcane, as a multi-faceted crop, is used as raw material for the production of sugar, ethanol, electricity, paper and other allied products. Consequently, overall demand for sugarcane is expected to increase many fold in the days to come. However, area under the crop is not likely to increase with the demand and therefore, increased demand for sugar is to be met only through vertical growth in sugarcane productivity and sugar recovery.

Thus sugar sector demands for steady increase in sugarcane production through sustained growth which provides ample opportunities to increase the farmers' income through optimal resource use and adoption of relevant and potential technologies by the farmers. A critical analysis of various issues to be addressed for ensuring growth sustainability and increasing income level of cane farmers revealed the

*Principal Scientist (Agronomy), ICAR – Indian Institute of Sugarcane Research, Lucknow – 226002

presence of following ground realities across the country:

Continued mono-cropping of sugarcane without crop rotation and organic recycling for several decades have depleted soil fertility considerably. It is reported that there is an estimated loss of 4.5 to 7.9% in sugarcane yield due to soil degradation in India.

Soil productivity has come down due to the degradation of the physical and chemical properties and decline in rhizosphere microbial activities. Decline in soil organic carbon content has been very apparent over the years affecting productivity. Many of sugarcane growing regions contain less than 0.5% soil organic carbon against the minimum required limit of 0.65% needed for effective response from applied inputs in sugarcane crop. About 7-8 lakh hectares area under the crop is affected by soil salinity and related problem limiting crop yield to great extent. Though the crop is moderately tolerant to salinity, losses are significant.

Climate change has significantly impacted sugarcane production system across the country with frequent droughts, floods and diseases. Approximately 2.97 lakh ha of sugarcane area is prone to drought, affecting the crop growth during its formative phase causing 30-50% reduction in yield. Floods and water logging are serious problems in eastern UP, Bihar, Odisha, Coastal Andhra Pradesh and parts of Maharashtra. Approximately 2.13 lakh ha is flood/water logging prone in different states. Water logging affects all stages of crop growth and can reduce germination, root establishment, tillering and growth which will lead to reduced yield of sugarcane and sugar.

Major diseases like smut, wilt and yellow leaf disease (YLD), are need to be managed effectively through tissue culture-based seed nursery programme combined with virus-indexing. Pests, particularly borer pests, continue to be a threat to sugarcane productivity and efforts for management of pests through behavioural, chemical and biological methods have been partially successful.

Increasing cost of cane cultivation is another major factor for decreasing farm income in the recent past. Sugarcane cultivation requires 300 to 350 man days during the crop season to perform operations like planting, inter-culture and harvesting. Decreasing working hours per unit of labour, quality of labour hours and ever increasing wages has resulted in the increased production cost.

There exists great scope for making sugarcane cultivation cost effective, especially through promoting resource conserving crop production technologies such as precise irrigation methods, site specific fertilizer application and adoption of soil health sustaining nutrient management techniques. Supporting farmers with timely weather forecast, weather and crop advisories, ICT based technology backstopping and farmer centric credit system and site specific insurance scheme would effectively overcome the emerging challenges prevailing in the cane production system.

Emerging crop scenario in sugarcane is multi-dimensional in terms of demand, production constraints, opportunities and technology landscape. To double the income of sugarcane growers, strategic planning becomes absolutely essential to tackle the core issues of cane cultivation viz., resources availability, investments to be made, technological requirements etc. It is imperative to visualise the emerging scenario and make a quantitative assessment of the sectoral needs and to evolve production targets to achieve doubling of farmers' income in a specified timeframe of 2022 in the country.

Sugarcane Production Scenario in States

Sugarcane in India is cultivated broadly under two distinct agro-climatic conditions commonly referred to as tropical and sub-tropical regions. Tropical region comprising the states viz., Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Telangana, Madhya Pradesh, Gujarat, Odisha and Chhatisgarh accounts for 42.9 % of total sugarcane area in India. Sub-tropical region on the other hand

consisting of Uttar Pradesh, Bihar, and Punjab, Haryana, Uttarakhand, West Bengal and north-eastern states contributes 57.1% of total crop area. Based on area spread (> 75000 ha) and magnitude of annual production during the last five years it emerges that only 11 states account for around 97% of the area and production of sugarcane in the country. Of these Uttar Pradesh is the main sugarcane growing state with 2.2 million ha area (43.7%) followed by Maharashtra (0.98 m ha). Other important states are Karnataka, Tamil Nadu, Gujarat, Andhra Pradesh, Telangana, Bihar, Haryana, Punjab and Uttarakhand.

Of the two agro-climatic regions, tropical region is more suitable for sugarcane growth and development owing to prevalence of round the year conducive climatic conditions for the crop. Moreover, sugarcane is grown for longer duration with high input application in this region that leads to low remuneration despite high productivity. The region contributes about 48% to the total cane production in the country with average productivity being 85 t/ha. Sub-tropical states face the extremes of temperature during summer and winter months that leads to comparatively shorter conducive growth period from July to November for sugarcane causing low average productivity of 59.3 t/ha which is 11 t/ha lower than the national average. Evident here is the fact that efforts to double the income of sugarcane farmers in these regions need to be based on addressing the region specific issues.

Region wise approach for doubling farmers' income

Plan of action for tropical India

Tropical states produce higher cane yield and better sugar recovery due to favourable climatic and socio economic status of cane farmers. Maharashtra, Karnataka and Tamil Nadu are leading sugarcane producers along with Gujarat and Andhra Pradesh. Considering homogeneity of production scenario in the region, ways and means to doubling farmer's income was summed up here.

Tamil Nadu ranks first in yield, similarly Karnataka and Maharashtra ranked second and third in India. Average level of productivity and net income is 80t/ha and Rs. 70000/ha, respectively. To double income of the farmers, yield has to be increased to 100 t/ha with other conditions remaining same. Increasing yield to achieve objective is daunting task, but, it is not beyond target. Yield and sugar recovery improvement could be possible by addressing the following constraints faced by the sugarcane farmers in this region.

i) Cultivation of tissue culture derived seeds/setts of improved varieties

ii) Mechanisation of farm operations

iii) Implementation of micro irrigation along with fertigation

iv) Mechanised harvesting

v) Ratoon management

Plan of action for sub-tropical India

Stagnant cane yield and low sugar recovery became identity of sugar mills in sub-tropical India. There was a challenge to break this jinx with large scale adoption of technological interventions. Income of farmers in sub-tropics is comparatively low due to low yield realisation in comparison with yield potential. Sugarcane is cultivated conventionally and introduction of modern technologies is need of the hour for doubling farmers' income in this region. Some of the proven varieties and technologies which are developed exclusively to sub-tropical India are explained to achieve desired objective.

Recommended technological interventions for enhancing input use efficiency for productivity improvement:

Technological	Recommended Technologies	Problems addressed and Expected Out Come
Land preparation	Laser leveller	Traditional methods of leveling are cumbersome, time consuming and with less accuracy. Precise leveling in short period of time is another advantage of laser leveling. Better distribution of water which will save around 20-25 % of irrigation water.
Variety	Location specific variety	Choice of correct set of varieties for a particular agro-climatic location is very vital in reaping best possible harvest, given other crop production and protection inputs in required measures
	Healthy seed	A good seed in sugarcane is defined as sett obtained from a healthy crop. It should be free from pests and diseases should have a good germination of more than 85%. Genetic purity of a variety which plays a pivotal role in sugarcane and sugar production should be maintained.
Planting system	Settlings Transplanting Technique (STT)	Conventional planting of sugarcane with three budded setts requires about 8-9 t/ha planting material. There is possibility of utilizing bud chips and single budded settlings as seed material. Only 12,500 settlings per hectare are required in case of bud chip planting. Using bud chips and raising settlings in a nursery can save 80 per cent of the seed material compared to three budded setts.
	Inter-cropping with short duration pulses and vegetables	Growing of legumes as intercrops can also result in improvement in soil fertility and additional income to the farmers. Green gram, black gram, soy bean, sun hemp, *dhaincha*, potato garlic, onion and pulses could be raised as intercrops in sugarcane. Additional income to farmers within short span of 65-90 days.
Water Management	Drip system of irrigation	About 40 % saving water and 25% increase in the yield It reduces labour requirement for irrigation. Effective application of inorganic fertilizers. Improvement in sugar recovery.
	Water conservation technologies	Mulching also suppresses weed growth besides conserving moisture. Wherever water is scarce, number of irrigations can be reduced by trash mulching and thus water can be saved.
Soil health management	Improving SOM content: Trash composting and bio-compost application	Maintains the soil fertility and sustainability of sugarcane productivity
	Reclamation of soil salinity and alkalinity	Increase the resource use efficiency and crop productivity
	Diagnosis of subsurface hard pan and chisel ploughing	Soil compaction can be a serious and unnecessary form of soil degradation that can result in increased soil erosion and decreased crop production. Compaction of soil is the compression of soil particles into a smaller volume, which reduces the size of pore space available for air and water.
Plant protection measures	Integrated Pest Management (IPM)	Sugarcane eco system is comparatively less prone to economic yield loss if properly managed at farmers' level. To manage any pest or disease the best approach is an integrated approach involving cultural, mechanical, biological and chemical methods.
Farm mechanisation	Mechanisation of farm operations	Mechanization is the immediate option through which there is possibility of minimizing expenditure on human labour. Timely intercultural operations Saves considerable amount of labour Reduces cost of cultivation Improvement in cane yield and sugar recovery

SUSTAINING SOIL FERTILITY THROUGH *IN SITU* CROP RESIDUE RECYCLING IN WINTER RICE-BASED CROPPING SYSTEMS OF ASSAM

Nilay Borah*, Kashyap Porag Bezbaruah, Suravi Nandy, Prantika Kakati and Anupama Das

Efficient in situ recycling of rice stubbles remains a major challenge in transplanted rice ecosystem irrespective of sole cropping or diversified rice-based cropping systems in Assam. In case of sole cropping, the rapid in situ composting methods are not feasible in terms of energy consumption and cost effectiveness. On the other hand, incorporation of rice stubble without succeeding crop may lead to significant loss of some of the available nutrients in later stages of decomposition coinciding with pre-monsoon and monsoon rains. The decomposition of left over stubbles following their incorporation just before the next rice crop, the usual practice followed in mono-cropping areas, had been implicated for adverse effects in terms of low carbon mineralization, methane emission, toxicity to roots etc. The stubble management needs careful approach for sustaining soil fertility and productivity of succeeding crop(s). The efficiency of rice stubble recycling is significantly influenced by stubble pre-treatment, choice of crop, establishment method, and nutrient and water management practices. The approach to in situ rice stubble management thus holds immense significance towards mission double cropping in transplanted rice fallow areas of the state for long term sustenance of crop productivity and soil fertility.

Introduction

About one third of the 686 million tonnes crop residue biomass generated annually in India is estimated as surplus (Hiloidhari *et al.*, 2014). After sugarcane, rice produces second highest crop residue biomass in the country. Burning of crop residues, rice stubble in particular, remains a major concern to excessive particulate matter emissions and air pollution largely due to lack of feasible *in situ* management practice (Bhuvaneshwari *et al.*, 2019). Winter rice is the major crop grown in Assam and the state had achieved a steady growth rate in productivity with little more than 10% increase in production during last decade. The efficient management of crop residues rice is an emerging issue and is expected to play a significant role for sustainability of crop productivity and soil resources, especially in winter rice growing areas (Borah *et al.*, 2017).

The *in situ* management of rice stubble is done mainly through direct incorporation into soils or using them as mulch. These methods had been recommended for adoption and promotion in India as part of the National Policy for 'Management of Crop Residue', not only to replace crop residue burning but also to prevent environmental degradation in the croplands (Anonymous, 2014). Besides, rapid *in situ* aerobic methods of composting are also available but these involve periodical spraying of moisture and turning of materials (Anonymous, 2000) and manual labour intensive not feasible for and preferred by the farming community. The success of using microbial consortium in co-composting of rice straw (Zhou *et al.*, 2015) with organic manure in saving carbon loss (Devi *et al.*, 2012) appears good for the environment and utilization of crop residues. However, the availability of specific microbe culture hinders adoption of such methods in larger areas and farm units. The *in situ* decomposition of rice stubble through spraying commercial yogurt as mixture with glyphosate solution had recently been reported (Borah *et al.*, 2016a; Borah *et al.*, 2016b; Borah *et al.*, 2016c). The formation of complexes between glyphosate and the Ca^{2+} ion (Madsen *et al.*, 1978; Thelen *et al.*, 1995) in yogurt facilitating absorption of the complex through the plasmalemma (Hetherington *et al.*, 1998) and glyphosate (N-Phosphonomethylglycine)

*Professor, College of Horticulture, Assam Agricultural University, Jorhat, Assam - 785013

degrading ability of bacteria present in yogurt (Fan *et al.*, 2012; Hallas *et al.*, 1992; Benslama and Boulahrouf, 2013) were cited as the mechanisms for success of the spray mixture for faster *in situ* decomposition of rice stubble.

Soil fertility status in rice-based cropping with retention of stubbles

Higher water use efficiency can be achieved in rice-field pea relay cropping through optimum time of sowing under rainfed condition (Sarma *et al.*, 2017) and harnessing the benefit of residual effect of organic manure applied to winter rice irrigation at flowering stage (Anonymous, 2011). Besides being profitable, pea as relay crop with winter rice in frequently flood affected sandbars can sustain available nutrient contents in soil, except nitrogen, for the succeeding crops (Talukdar *et al.*, 2009). The benefit of the relay crop may vary with soil type and crop intensification. Inclusion of green gram as third crop in rice-relay cropping showed higher positive effect on soil available N, P and K build up with toria and niger than lentil and pea as the relay crops in sandy loam soils (Deka *et al.*, 2019). While both lentil and pea contributed equally to soil fertility status, pea with higher yield removed more nutrients than lentil in the cropping system. In case of toria and niger, in spite of relatively higher amounts of fertilizer P and K added in the system with the former, the positive balance in soil nutrient status was less due to greater removal of nutrients from soil. The recommended doses of fertilizer may be applicable for specific crop like linseed (Kalita, 1999), while addition of farmyard manure enabled fifty per cent reduction in the recommended dose of fertilizer in achieving maximum yield and monetary benefit in crops like niger (Gogoi, 2006) as relay cropping to winter rice.

Soil fertility status in rice-based cropping with incorporation of stubbles

Incorporation through conventional tillage significantly increased available nutrients in soil and yield and nutrient uptake in linseed (*Linum usitassimum* L.) under irrigated condition in comparison to complete removal of rice stubbles (Borah, 2011). However, the feasibility of rice stubble incorporation with assured irrigation in the succeeding crop is specific to land situation and ease of farm machinery operation, in spite of potentially higher water use efficiency through residual and added soil moisture. Further, the choice of succeeding crop also affects the efficiency of *in situ* crop residue management as incorporation of rice stubble without pre-treatment may induce immobilization of native nitrogen leading to its short-term deficiency in crops like wheat (Anonymous, 1996) compared to toria, pulses and vegetables. Incorporation of rice stubble treated with commercial yogurt-glyphosate mixture increased available nutrients in soil and succeeding green gram yield, but loss of potassium without crop compared to retention of stubbles (Bezbaruah, 2017). Potassium is taken in large quantity by rice crop but do not get utilized properly and once the crop is harvested, 70-80 per cent of potassium gets leached out from the stubble after dessication (Rosolem *et al.,* 2005) and added to the soil. Thus, incorporation of rice stubble without succeeding crop would cause leaching of soluble potassium from the soil because of the pre-monsoon rains. Supplementing zinc fertilizer with recommended doses of N, P and K fertilizers with incorporation of rice stubble is required to sustain and improve available nutrient status in soil under transplanted rice-rice cropping system (Baishya *et al.*, 2017). Rice stubble incorporation in transplanted rice-rice cropping sequence with recommended doses of fertilizer and organic manure had been shown to increase forms of potassium (Chanu, 2015), and nitrogen (Miranda, 2015), while the macronutrients did not show significant variations (Fanai, 2014), low available boron content of soil was reported for rice-rice than that of rice-rapeseed or rice-vegetable cropping systems (Nath, 2013). Incorporation of rice stubbles treated with yogurt-glyphosate mixture had differential effects on mineralization of carbon and nitrogen under continuous field capacity moisture regime (Nandi 2019). The easily oxidizable carbon in soil increased significantly due to incorporation of rice stubble after 2nd week till the 15th week of incubation compared to its removal. The ammonium-nitrogen (NH_4-N) in soil

significantly increased due to incorporation of *yogurt* treated rice stubble compared to untreated rice stubble, while compared to removal of rice stubbles, their addition had a significant effect on nitrate-nitrogen (NO_3-N) content in soil irrespective of the pre-treatment.

Conclusion

The benefits of *in situ* recycling of crop residues in winter rice-based cropping system, either through their retention or incorporation, is influenced by soil environment, pre-treatment of the stubbles, succeeding crop and nutrient management practices. The effects of recycling rice stubble on soil fertility status need to be evaluated for long-term practices on establishment methods, nutrient management and crop diversification.

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WEATHER FORECAST BASED AGRONOMIC INTERVENTIONS FOR DOUBLING FARMER'S INCOME IN CHANGING CLIMATE

N. K. Pareek*

Agriculture crop dynamics are influenced by multiple factors such as the type of the crop, location, and weather. To improve agriculture productivity, farmers need integrated agricultural advice that consists of advice for crop protection and production problems, and appropriate risk mitigation steps based on the expected (normal and deviated) weather pattern. Climate is a measure of the average pattern of variation in temperature, humidity, atmospheric pressure, wind, precipitation, atmospheric particle count and other meteorological variables in a given region over long periods of time. Climate is different from weather, in that weather only describes the short-term conditions of these variables in a given region. Climate is considered as a constraint, as a hazard or as a resource. In every society climate is a mix of all three, but the proportions vary from one country to the other and from one time period to the other. When there is any trend is observed in the climate of the place is known as climate change.

Global climatic changes can affect agriculture through their direct and indirect effects on the crops, soils, livestock and pests. An increase in atmospheric carbon dioxide level will have a fertilization effect on crops with C_3 photosynthetic pathway and thus will promote their growth and productivity. The increase in temperature, depending upon the current ambient temperature, can reduce crop duration, increase crop respiration rates, alter photosynthate partitioning to economic products, affect the survival and distribution of pest populations, hasten nutrient mineralization in soils, decrease fertilizer-use efficiencies, and increase evapo-transpiration rate. Indirectly, there may be considerable effects on land use due to snow melt, availability of irrigation water, frequency and intensity of inter- and intra-seasonal droughts and floods, soil organic matter transformations, soil erosion, changes in pest profiles, decline in arable areas due to submergence of coastal lands, and availability of energy. Equally important determinants of food supply are socio-economic environment, including government policies, capital availability, prices and returns, infrastructure, land reforms, and interand intra-national trade that might be affected by the climatic change. Different weather parameters such as Temperature (Max. and Min.), Precipitation/Rainfall, Wind speed and direction, Cloudiness, Soil moisture and Temperature, Humidity, Dew duration (especially in arid regions) and Dry & wet spells play an important role in the development and growth of plants.

Each agronomic intervention like field preparation, selection of crop and varieties, deciding about optimum sowing time, seed rate, manure and fertilizer application, irrigation scheduling, top dressing and foliar spray of pesticides, weed, disease and insect-pest management, harvesting, threshing and storage of produce and even marketing of the produce in the *MANDHIS*, all are decided by climate and prevailing weather conditions of a particular place. It is therefore, getting information on these weather variables in the particular area of concern is very much important. In the era of climate change, it is utmost important to draw attention for taking decisions of agronomic interventions considering the weather forecast issued by the India Meteorology Department and its regional centres.

Weather forecasting: Forecasting is a matter of charting atmospheric conditions and interpolating them in such a way as to be able to foresee the state of weather in future. It is defined as, "Application of science and technology to predict the state of atmosphere for a given location."

*Assistant Professor, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner – 334006, Rajasthan

Weather forecasts can be broadly classified into four categories.

- Now casting : validity upto few hours.
- Short Range Forecasting : validity for less than 3 days.
- Medium Range Forecasting : validity from 3 to 10 days.
- Long Range Forecasting : validity beyond 10 days to a few weeks or a month or a season oreven beyond

A farmer requires the weather and climatic information for planning different operations:

- The short range weather forecasts are helpful in day-to-day operational activities.
- The medium range forecasts are useful for taking measures to offset ill effects on crops in the field and for planning routine operational activities.
- Thelong-range forecasts help in planning of future cropping system and in arranging the required inputs.

Agricultural operations based on the type of forecast

- Nowcasting – Protecting from Extreme weather events
- Short range forecast – Application of irrigation water, fertilizers, harvesting etc.,
- Medium range forecast – Sowing, transplanting, irrigation, fertilizers, plant protection measures, harvesting and threshing etc.,
- Extended Range Forecast – In-season decision making and Crop contingency planning
- Long range forecast – Crop planning, Selection of cultivar, Input and field preparation, Contingency planning etc.,

Validity period of forecast has inverse relationship with its accuracy. Though, now casting has highest accuracy, but it has least response time to react accordingly. The medium range forecast has good amount of accuracy and also has sufficient time to respond, therefore Government of India had established National Centre for Medium Range Weather Forecasting for improving the quality of medium range forecast. India Meteorological Department has taken major initiative to implement innovative and state of art technologies which are essential to address the above mentioned issues of weather and climate on Indian agriculture and also to realize the present day needs of the farmers of the country and also to meet the demands of the poorer section of the country.

India Meteorological Department (IMD) started Integrated Agro-Meteorological Advisory Service (IAAS) in the country for the benefits of farmers. Agro advisory (AAS) is the agro meteorological forecast issued in the favour of farmers of the agro climatic zone to enable them to adjust their farm operations as per the prevailing and forecasted weather conditions.Agro-meteorological service rendered by IMD, Ministry of Earth Sciences is an innovative step to contribute to weather information based crop/livestock management strategies and operations dedicated to enhancing crop production by providing real time crop and location specific agromet services with outreach to village level. The IAAS provides a very special kind of inputs to the farmer as advisory bulletin. It has made a tremendous difference to the agriculture production by taking the advantage of benevolent weather and minimizes the adverse impact of malevolent weather.

IMD launched the scheme IAAS in the country in collaboration with different organizations/ institutes/stakeholders from 1st April 2007 for weather wise farm management. Under IAAS, a

mechanism was developed to integrate weather forecast, climatic and agro-meteorological information to prepare agro-advisories which contribute significantly to enhance farm productivity and trying to solve the food security in India.This project is implemented through five tier structure to set up different components of the service spectrum. It includes meteorological (weather observing & forecasting), agricultural (identifying weather sensitive stress & preparing suitable advisory using weather forecast), extension (two way communication with user) and information dissemination (Media, Information Technology, Telecom) agencies. From 1 June, 2008 quantitative district level weather forecast up to 5 days is issued. The product comprises of quantitative forecasts for 7 weather parameters viz., rainfall, maximum and minimum temperatures, wind speed and direction, relative humidity and cloudiness. In addition, weekly cumulative rainfall forecast is also provided. IMD, New Delhi generates these products using Multi Model Ensemble technique based on forecast products available from number models of India and other countries. The products were disseminated to Regional Meteorological Centres and Meteorological Centres of IMD located in different states. These products after value addition using synoptic interpretation of model output are communicated to 130 Agro Met Field Units (AMFUs) co-located with State Agriculture Universities (SAUs), institutes of Indian Council of Agriculture Research (ICAR), Indian Institute of Technology (IITs) etc., for preparation of district level agro-met advisories twice a week i.e. Tuesday and Friday. At Each AMFU, an advisory board constituting experts from various disciplines give their input to improve the quality and usability by the end users. In AAS, we are more concern about Medium *Range Forecasting to issue* District level weather forecast up to 5 days including 7 weather parameters viz. Rainfall, Wind speed and direction, Maximum temperature, Relative humidity, Minimum temperature and Cloud cover. In addition, Weekly cumulative rainfall forecast is also provided.

AAS Bulletins at Different Level

The Agromet Advisory Bulletins are issued at district, state and national levels. The district level bulletins are issued by AMFUs and include crop specific advisories including field crops, horticultural crops and livestock. The State Level bulletin jointly prepared by State Meteorological Centre of IMD and AMFUs is a composite of district bulletins helping to identify the distressed districts of the state as well as plan the supply of appropriate farm inputs such as seeds, irrigation water, fertilizer, pesticides etc. It forms a significant input to the State level weekly Crop Weather Watch Group (CWWG) meeting and used by state government line function departments viz: Fertilizer industry, Pesticide industry, Irrigation Department, Seed Corporation, Transport and other organizations which provide inputs in agriculture. National Agromet Advisory Bulletins are prepared by National Agromet Advisory Service Centre, Division of Agriculture Meteorology, IMD, Pune, using inputs from various states. This bulletin helps identify stress on various crops for different regions of the country and suitably incorporate advisories.

Ministry of Agriculture is prime user of these bulletins, as important decisions are taken in weekly Crop Weather Watch Group meetings steered by Ministry of Agriculture at national level. The bulletins are also used by a large number of other agencies including fertilizer, pesticide industries. At present bulletins are being issued twice in a week i.e., Tuesday and Friday and reach 23 state and 560 district level centres.

District-specific medium-term forecast information and advisories help to maximize output and avert crop damage or loss. It also helps growers anticipate and plan for pesticide applications, irrigation scheduling, disease and pest outbreaks and many more weather related agriculture-specific operations. Such operations include cultivar selection, their dates of sowing/ planting, dates of intercultural operations, dates of harvesting and also performing post-harvest operations. Agromet advisories help increase profits by consistently delivering actionable weather information, analysis and decision support for farming situations such as: to manage pests through forecast of relative humidity, temperature and wind; manage

irrigation through rainfall & temperature forecasts; protect crop from thermal stress through forecasting of extreme temperature etc.

Components of agromet-advisory Bulletins

Weather/Climate information

- Summary of preceding week,
- Climatic normal for the week, Weather
- Medium Range Weather forecast

Crop information

- Type, state and phenological stages
- Information on pest and disease and
- Information on crop stresses

Advisory For weather wise farm management

- Crop-wise farm management information tailored to weather sensitive agricultural practices like sowing, irrigation scheduling, p & d control operation, fertilizer use etc.
- Spraying condition for insect, weed and their products
- Livestock management information for housing, health and nutrition etc.

A typical Agromet Advisory Bulletin enables farmers to reap benefits of benevolent weather and minimize or mitigate the impacts of adverse weather are:

- District specific weather forecast, in quantitative terms, for next 5 days for weather parameters like rainfall, cloud, maximum/minimum temperature, wind speed/direction and relative humidity, including forewarning of hazardous weather events (cyclone, hailstorm, heat/cold waves, drought and flood etc) likely to cause stress on standing crop and suggestions to protect the crop from them.
- Weather forecast based information on soil moisture status and guidance for application of irrigation, fertilizer and herbicides etc.
- Advisories on dates of sowing/planting and suitability of carrying out intercultural operations covering the entire crop spectrum from pre-sowing to post harvest to guide farmer in his day–to-day cultural operations.
- Weather forecast based forewarning system for major pests and diseases of principal crops and advises on plant protection measures.
- Propagation of techniques for manipulation of crop's microclimate e.g. shading, mulching, other surface modification, shelter belt, frost protection etc. to protect crops under stressed conditions.
- Reducing contribution of agricultural production system to global warming and environment degradation through judicious management of land, water and farm inputs, particularly pesticides, herbicides and fertilizers.
- Advisory for livestock on health, shelter and nutrition.

The support on above is rendered through preparing district specific agro meteorological advisory bulletins which are tailored to meet the farmers' need and are made relevant to his decision making

processes. The suggested advisories generally alter actions in a way that improves outcomes as it contains advice on farm management actions aiming to take advantage of good weather and mitigate the stress on crop/livestock. The bulletins are encoded in a format and language which is easy to comprehend by the farmer. The Technical officer appointed in each unit of AMFU first interpret the immediate past weather and the forecast for next 5 days and translate it into layman's terms so that the farmers can understand it. They use state-of-art technology such as crop weather calendars, crop weather models, climatic risk management tools, GIS generated agromet products such as NDVI and SPI maps etc., for framing the advisory bulletins. Also, interaction between the AMFUs and farmers to identify the weather sensitive decisions is promoted under the service through participatory approach. This step fosters a relationship between the IMD, AMFUs, farmers and other stakeholders so that they can identify or diagnose the gaps in weather information and services available from the IMD.

In recent days, lot of emphasis is being given on weather based forecasting models for prediction of disease outbreak. Hashiba *et al*. (1982) observed that sheath blight disease development was most favourable at a temperature of 28°C and 100% relative humidity with continuous low precipitation during the time of disease development. However, the environmental conditions of different regions of the country differ a lot due to their geographical variations. Hence need was felt for thorough understanding on the weather parameters of west central table land zone of Odisha to study the weather relationship of the disease so as to predict, forecast and plan for effective protection measures. Considering the intensity of the disease, the present experiment was undertaken to find out the influence of weather parameters on the initiation and progression of sheath blight disease in west central table land zone of Odisha.

To downscale the service from district level to block level, a memorandum of understanding (MoU), was signed between ICAR and IMD.ICAR & IMD have jointly planned to augment the AAS network to sub-district (block level) level by setting up of District Agro-Met Units (DAMUs) in 530 districts in the premises of KVKs to provide agromet services to farmers.

Economic Impact of AAS

- Economic Assessment by NCAP on IAAS estimated 10-25% economic benefit obtained by the farmers.
- Potential economic benefit estimated by NCAER, Rs.50,000crores per year (used by 24% farmers).
- Extrapolation can rise to Rs. 211,000 crores if the entire farming community were to apply Agromet information to their agricultural activity.

This indeed has a potential to change the face of India in terms of food security and poverty alleviation. If properly adopted and popularize among the various stake holders income of the farmers can be increased manifolds by minimizing the losses due to adverse weather events and also suggesting best agro techniques by which farmers can get benefits, if timely informed.

SOIL BIODIVERSITY AND ITS MANAGEMENT FOR SUSTAINABLE AGRICULTURE

Sanjay Arora[1*], Divya Sahni[2], Y.P. Singh[1] and A.K. Singh[1]

Soil is by far the most biologically diverse part of Earth. Soil is a complex and dynamic biological system, and still it is difficult to determine the composition of microbial communities in soil. The soil microorganisms are an integral part of agricultural ecosystems as they play a critical role in maintaining soil health, ecosystem functions and crop production. The soil food web includes beetles, springtails, mites, worms, spiders, ants, nematodes, fungi, bacteria, and other organisms. These organisms improve the entry and storage of water, resistance to erosion, plant nutrition, and break down of organic matter. Stability of ecosystem is another ecological concept and had strong relationship with biodiversity. Soil biological processes and soil biodiversity are central to the soil fertility and soil physical properties. Therefore, an understanding of microbial diversity is of paramount importance and requires immediate attention in order to maintain/improve soil health.

Introduction

Soil, a dynamic living matrix, is an essential part of the terrestrial ecosystem. It is a critical resource not only to agricultural production and food security but also to the maintenance of most life processes. Soils contain enormous numbers of diverse living organisms assembled in complex and varied communities ranging from the myriad of invisible microbes, bacteria and fungi to the more familiar macro-fauna such as earthworms and termites. The diversity in soils is several times higher than that above ground. Each hectare top soil contains approximately 1000 kg of different fungi, 500 kg of bacteria, 750 kg actinomycetes and 150 kg of algae and many protozoa (Table 1). These diverse microorganisms interact with one another and with the plants and animals in the ecosystem forming a complex system of biological activity. Environmental factors, such as temperature, moisture and acidity, as well as anthropogenic actions, in particular, agricultural practices affect soil biological communities and their functions to different extents. Diversity of soil microorganisms has emerged in the past decade as a key area of concern for sustainable soil health and crop production. Besides, the well-being and prosperity of earth's ecological balance, the sustainability of agricultural production systems directly depends on the extent and status of microbial diversity of soil.

Table 1. Important soil microorganisms, their number and biomass in cultivated soil

Group of microorganism	Average population (g^{-1} soil)	Average biomass (Kg ha^{-1})
Bacteria	10^7-10^8	500
Fungi	10^5-10^6	1,000
Actinomycetes	10^6-10^7	750
Algae	10^3-10^4	150

Soil microorganisms are an integral part of agricultural ecosystems; and they play a critical role in maintaining soil health, ecosystem functions and crop production. Some of the important functions carried out by microorganism in soil are:

*[1]Principal Scientist; [2]SRF, ICAR-CSSRI, RRS, Lucknow (U.P.)

- The activities of certain microorganism such as fungi, algae and bacteria affect soil structure by encouraging soil aggregation. This directly affects various soil physical properties and determines vulnerability to soil erosion;
- Soil microorganisms are central to decomposition processes and nutrient cycling in soil–plant–animal continuum. They, therefore, affect plant growth and productivity as well as the release of nutrients and pollutants in the environment, for example the leaching of nitrates into water resources;
- Certain soil organisms can be detrimental to plant growth by causing plant diseases. However, they can also protect crops from pest and disease outbreaks through biological control and reduced susceptibility;
- The activities of certain organisms determine the carbon cycle - the rates of carbon sequestration and gaseous emissions and soil organic matter transformation;
- Symbiotic relationships, especially of *Rhizobium* bacteria and Mycorrhiza, with crop plants play a key role in the uptake of nutrients and water, and contribute to the maintenance of soil porosity and organic matter content, through their growth and biomass;
- A group of soil microorganisms, referred as plant growth promontory rhizobacteria (PGPR), secrete plant growth hormones such as IAA, GA, cytokinin and enhance seed germination, root development and plant growth.
- Soil organisms can also be used to reduce or eliminate environmental hazards resulting from accumulations of toxic chemicals or other hazardous wastes (bioremediation).

Biodiversity

The term biodiversity refers to the variability and richness of species in an ecosystem. A species could broadly be defined as a collection of populations that may differ genetically from one another to a greater or lesser degree, but whose individuals are able to mate and produce offspring. Species are the most useful units for biodiversity research, and species diversity is the most useful indicator of biodiversity. At its lowest level, biodiversity depends on the sequences of genes in living organisms. Genes are composed of stretches of DNA, and these sequences, along with the proteins encoded by the genes, are almost identical to their counterparts in other species. Thus, they are said to be highly conserved across species, and such commonalities (or even differences) are referred to as genetic diversity. The importance of genetic diversity is observed in the combination of genes within an organism (the genome), the variability in the proteins or traits (phenotype) that they produce, and their resilience, survival and function. Biodiversity has three interrelated elements: genetic, functional and taxonomic diversity (Fig 1). Taxonomic diversity, i.e. the number of species, is an important part of an ecosystem's diversity and this is controlled by the genetic diversity, which may be greater than the number of recognized species. Several species may have the same functions, resulting in diverse functions called functional diversity. Biodiversity is, therefore the interaction of all these elements.

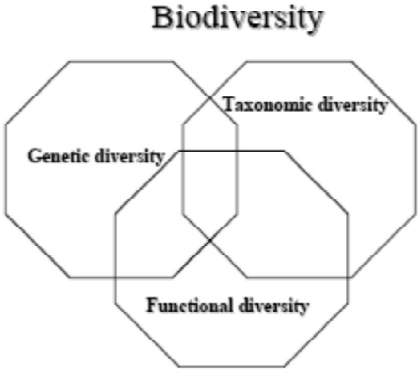


Fig 1. Inter-related elements of soil biodiversity

Soil biodiversity

Soil biodiversity reflects the mix of living organisms in the soil. These organisms interact with one another and with plants and small animals forming a web of biological activity. Soil is by far the most biologically diverse part of Earth. The soil food web includes beetles,

springtails, mites, worms, spiders, ants, nematodes, fungi, bacteria, and other organisms. These organisms improve the entry and storage of water, resistance to erosion, plant nutrition, and break down of organic matter. A wide variety of organisms provides checks and balances to the soil food web through population control, mobility, and survival from season to season.

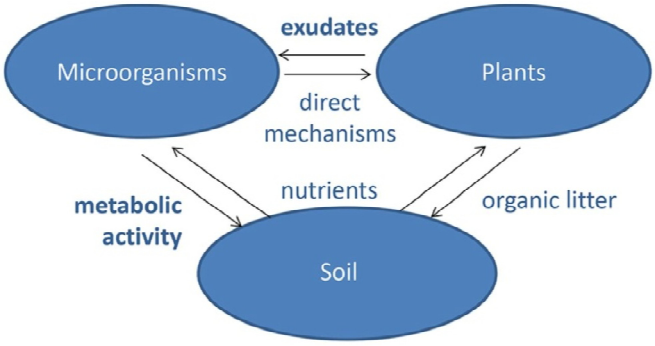
Microbial diversity in soil

A variety of microorganisms are present in soil, though the space occupied by living organisms is less than 5% of the total space. Therefore, microorganisms' remains confined to the hot spots i.e. aggregates with accumulated organic matter and rhizosphere. Each gram of soil has approximately 10^9 bacterial cells, 10^8culturable bacteria, 10^4 bacterial species, 10^5actinomycete cells and 10^5 fungal propagules. Bacteria in soil have varying mode of nutrition and can use sun light or chemical energy source. They can meet their carbon requirement from atmospheric CO_2 or organic compounds. Some take their nutrition from native organic matter or freshly added organic matter. The dominating soil bacteria include many species of *Arthrobacter, Pseudumonas, Bacillus, Xanthomonas, Clostridium, Azotobacter, Rhizobium* etc. The most dominating actinomycetes in soil is*Streptomyces.* Several genera of blue green algae, protozoa and algae are present in soil. All the soil microorganisms have great diversity in their physiological activities and functions. On the basis of temperature requirement, they are thermophillic, mesophillic and psychrophillic. Some requires O_2 for respiration (aerobic) while others can survive in absence of O_2. The earlier taxonomic classification of soil microorganisms is under process of tremendous change which can be noticed that root nodule rhizobia now has 36 species distributed among seven genera (*Allorhizobium, Azorhizobium, Bradyrhizobium, Mesorhizobium, Methlyorhizobium, Rhizobium, Sinorhizobium*). Plants play an important role in selecting and enriching the type of bacteria by constituents of their root exudates. The microbial community of wheat was studied extensively in Indo Gangetic plain and it was observed that wheat genotype did not appreciably influence the total bacterial and pseudomonad populations. However, population was marginally different in rhizosphere and rhizoplane fractions. It was also reported that plants exert a strong influence on the composition of microbial communities in soil through rhizodeposition and the decay of litter and roots. The link between plant species and microbial communities in the rhizosphere soil is strict, being the result of co-evolution. Scientists suggested that competition in microbial communities of surface soils with prevalence of any microbial species was absent because the various microbial species inhabiting soil are spatially separated for most of the time. They assumed that the contact among microhabitats occur for a very short time immediately after rain, when water bridges are formed between the various soil particles and aggregates. Rapid drainage maintains the spatial isolation among the various microhabitats of soil. However, it does not take into account the mixing and transport by soil fauna and the stability of communities in biofilms at the interface between roots and soil which are not so strongly affected by wetting and drying. An alternative hypothesis to explain the large microbial diversity of surface soil is based on the presence of a greater variety and content of organic compounds than in deeper soil layer. This supports the diverse heterotroph-dominated microbial community in surface soil.

Microbial diversity and soil functions

Relationship between biodiversity and functions of terrestrial ecosystems is best described by the hump-shaped curve, in which there is an increase in plant production (i.e. the function) with increasing biodiversity until a certain point is reached; then a further increase in biodiversity results in a decrease in plant production. Stability of ecosystem is another ecological concept and had strong relationship with biodiversity. Stability is defined as the property of an ecosystem to withstand perturbations. Stability includes both resilience (i.e. the property of the system to recover after disturbance) and resistance (i.e. the inherent capacity of the system to withstand disturbance). It is difficult to measure both resistance

and resilience in soil. Generally microbe-mediated processes are the most sensitive to perturbations in the soil; for this reason the capacity of soil to recover from perturbations can be assessed by monitoring microbial activities. The links between microbial diversity and soil functioning, as well those between stability (resilience or resistance) and microbial diversity in soil, are unknown because, as stated above, it is difficult to measure microbial diversity. Therefore, soil functions are measured by determining the rates of microbial processes, without knowing the microbial species effectively involved in the measured process. According to O'Donnell *et al.* (2001), the central problem of the link between microbial diversity and soil function is to understand the relations between genetic diversity and community structure and between community structure and function. From a study it was found that soil fumigated with chloroform, with a much smaller microbial biomass than the corresponding non-fumigated soil, respired about the same amount of $^{14}C\text{-}CO_2$ from labelled straw as the non-fumigated soil. They also found that pollution with zinc affected respiration of non-fumigated and fumigated soils in the same way, indicating that the ratio between substrate C-to-microbial biomass C (larger in the fumigated than the non-fumigated soil) was not important. The ratio of CO_2 to ^{14}C-to-microbial biomass ^{14}C was linearly related to Zn pollution. It was reported that soil fumigated with chloroform, with greater microbial diversity, was more resistant and resilient than soil with a less diverse community to perturbations such as heating at 40^0C for 18 hours or treatment with 500 mg Cu g^{-1} soil. However, they suggested that the observed effects were due to the physiological influence of $CHCl_3$ fumigation on the microbial community rather than differences in microbial diversity.



Soil microorganisms and functions

Impact of agricultural practices

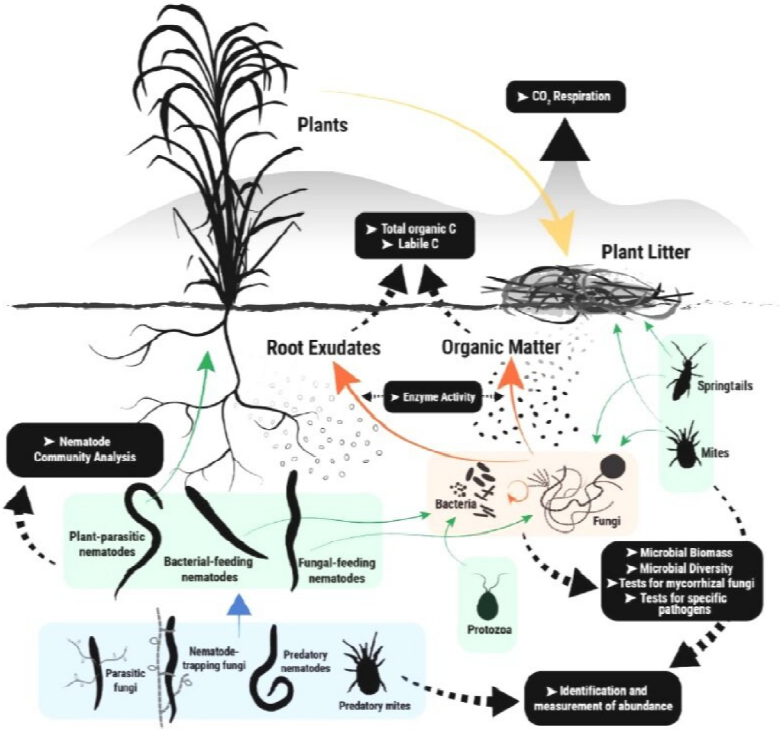
Changes in environment affect both the number and kinds of soil organisms. Various agricultural management practices like tillage, cropping systems, fertilizer application, cultivation practices, soil organic amendments and pesticide application alter the microbial dynamics in the agro ecosystem. Tillage is practiced to destroy weeds, incorporate plant residue into the plough layer, destroy plant residues harbouring plant pathogens, and provide better soil structure for easy emergence of seedlings and for proper root growth. Labile organic reserves in soil generally decrease with cultivation and cropping and therefore, alter the microbial diversity and biomass in soil. These effects of tillage are largely confined to the surface (5-10 cm) soil layer. It has been reported that an increase in phosphatase and dehydrogenase activities and contents of moisture and, organic C and N in the surface (0 to 7.5 cm) of no- till soil compared to conventional tillage. However, at the 7.5 to 15 cm and 15 to 30 cm depths these trends were reversed and microbial populations, enzyme activities and moisture and organic C and N contents were the same or higher for conventional tillage than for no-till soil. Monoculture a practice of growing one crop year after year on the same piece of land is a result of newer innovations in the field of agriculture. This involves use of improved crop varieties, pesticides, inorganic fertilizer and has selective effect on microbial diversity. Wheat genotypes grown in Indo- Gangetic plains did not significantly influence the total bacterial and pseudomonad population in soil, however, she reported distinct cluster of rhizosphere communities of wheat and mandua (*Eleusins coracana*) grown at Chaukhutia, Almora using 16S rDNA restriction profile. Crop rotation length, fallow substitute crops and fertilization also affect the microbial diversity in soil. Soil under continuous cropping has higher biomass C and N than soil under fallow and cropping + fallow soils. These variations could be explained in terms of substrate availability. While

studying the effect of different cropping sequences on chemical and microbiological properties it was reported maximum total N and organic matter content under early pigeonpea-lentil-greengram rotation. However, the population of bacteria was maximum under pigeonpea-maize-wheat rotation and that of fungi under maize-lentil rotation. Population of actinomycetes was not affected by different cropping sequences. Results of the long term experiment conducted with the application of N and P fertilizers indicated that total viable bacterial numbers increased with the addition of fertilizers and the highest population was detected in treatment with normal doses of NPK. However, selective influence of fertilizer application is observed on AMF species. *Acaulospora* sp.1 showed no change in spore number with fertilization whereas *Entrophosporas chenckii*, *Glomus mosseae*, *Glomous* sp.1, *Scutellospora fulgida* showed a decline in absolute number in response to fertilization. The effects of fertilizer applications on soil microbial biomass were due to an increase in root biomass, root exudates and crop residues thus providing increased substrate for microbial growth. Most pesticides applied at rates approximating those used in field applications caused only slight change in population and activities of micro-organisms, however, affected soil microorganisms adversely at high rates of application. The effects of three post- emergence herbicides (2, 4-D, Picloram and glyphosate) on certain microbial variables was reported by scientists who concluded that the changes in microbial parameters measured as microbial numbers and soil respiration, occurred only at herbicide concentrations of much higher than that used for field application and the side effect of these chemicals were probably of little ecological significance.

Benefits of soil organisms

Residue decomposition

Soil organisms decompose plant residue. Each organism in the soil plays an important role. The larger organisms in the soil shred dead leaves and stems. This stimulates cycling of nutrients. The larger soil fauna include earthworms, termites, pseudoscorpions, microspiders, centipedes, ants, beetles, mites, and springtails. When mixing the soil, the large organisms bring material to smaller organisms. The large organisms also carry smaller organisms within their systems or as "hitchhikers" on their bodies. Small organisms feed on the by-products of the larger organisms. Still smaller organisms feed on the products of these organisms. The cycle repeats itself several times with some of the larger organisms feeding on smaller organisms. Some larger organisms have a life span of two or more years. Smaller organisms generally die more quickly, but they also multiply rapidly when conditions are favorable. The food web is therefore quick to respond when food sources are available and moisture and temperature conditions are good.



Soil food web

Infiltration and storage of water

Channels and aggregates formed by soil organisms improve the entry and storage of water. Organisms mix the porous and fluffy organic material with mineral matter as they move through the soil. This mixing action provides organic matter to non-burrowing fauna and creates pockets and pores for the movement and storage of water.

Fungal hyphae bind soil particles together and slime from bacteria help hold clay particles together. The waterstable aggregates formed by these processes are more resistant to erosion than individual soil particles. The aggregates increase the amount of large pore space which increases the rate of water infiltration. This reduces runoff and water erosion and increases soil moisture for plant growth.

Nutrient cycling

Soil organisms play a key role in nutrient cycling. Fungi, often the most extensive living organisms in the soil, produce fungal hyphae. Hyphae frequently appear like fine white entangled thread in the soil. Some fungal hyphae (mycorrhizal fungi) help plants extract nutrients from the soil. They supply nutrients to the plant while obtaining carbon in exchange and thus extend the root system. Root exudates also provide food for fungi, bacteria, and nematodes.

When fungi and bacteria are eaten by various mites, nematodes, amoebas, flagellates, or ciliates, nitrogen is released to the soil as ammonium. Decomposition by soil organisms converts nitrogen from organic forms in decaying plant residues and organisms to inorganic forms which plants can use.

Management considerations

Cultivation

The effects of cultivation depend on the depth and frequency of the cultivation. Tilling to greater depths and more frequent cultivations has an increased negative impact on all soil organisms. No-till, ridge tillage, and strip tillage are the most compatible tillage systems that physically maintain soil organism habitat and biological diversity in crop production.

Compaction

Soil compaction reduces the larger pores and pathways, thus reducing the amount of suitable habitat for soil organisms. It also can move the soil toward anaerobic conditions, which change the types and distribution of soil organisms in the food web. Gaps in the food web induce nutrient deficiencies to plants and reduce root growth.

Pest control

Pesticides that kill insects also kill the organisms carried by them. If important organisms die, consider replacing them. Plant-damaging organisms usually increase when beneficial soil organisms decrease. Beneficial predator organisms serve to check and balance various pest species. Herbicides and foliar insecticides applied at recommended rates have a small impact on soil organisms. Fungicides and fumigants have a much greater impact on soil organisms.

Fertility

Fertility and nutrient balances in the soil promote biological diversity. Typically, carbon is the limiting resource to biological activity. Plant residue, compost, and manure provide carbon. Compost also provides a mix of organisms, so the compost should be matched to the cropping system.

Cover crops and crop rotations

The type of crops that are used as cover or in crop rotations can affect the mix of organisms that are in the soil. They can assist in the control of plant pests or serve as hosts to increase the number of pests. Different species and cultivars of crops may have different effects on pests. However, the organisms and their relation to the crop are presently not clearly understood.

Crop residue management

Mixing crop residue into the soil generally destroys fungal hyphae and favours the growth of bacteria. Since bacteria hold less carbon than fungi, mixing often releases a large amount of carbon as carbon dioxide (CO_2). The net result is loss of organic matter from the soil.

When crop residue is left on the soil surface, primary decomposition is by arthropod shredding and fungal decomposition. The hyphae of fungi can extend from below the soil surface to the surface litter and connect the nitrogen in the soil to the carbon at the surface. Fungi maintain a high C:N ratio and hold carbon in the soil. The net result is toward building the carbon and organic matter level of the soil. In cropping systems that return residue, macro-organisms are extremely important. Thus, it is important to manage the soil to increase their diversity and numbers.

Conclusion

Soil biological processes and soil biodiversity are central to the soil fertility and soil physical properties. Therefore, an understanding of microbial diversity is of paramount importance and requires immediate attention in order to maintain/improve soil health. Our understanding of the links between microbial diversity and soil functions is poor because measurement of all soil microorganisms is not easy; most are unculturable, even molecular techniques cannot detect all unculturable microorganisms. In addition, the present assays for measuring microbial functions determine the overall rate of entire metabolic processes, such as respiration, or specific enzyme activities, without identifying the active microbial species involved in it. The central problem of the link between microbial diversity and soil function is to understand the relations between soil genetic diversity and microbial community structure and between community structure and soil function. The recent advances in RNA extraction from soil might permit us to determine active species in soil. Further, advances in understanding require determining the composition of microbial communities and microbial functions in microhabitats. The research priorities needed to address in future includes; 1) assessment of the total genetic diversity of soil, 2) to establish the link between microbial species and/or communities and soil functions, 3) to monitor changes in microbial communities due to agricultural practices and other perturbation and 4) identifying potential indicators of microbial diversity and soil quality.

ABSTRACTS

1

CONSERVATION AGRICULTURE PRACTICES AND SOIL CARBON LOSS THROUGH EROSION IN SHIVALIKS

Divya Sharma, Vikas Sharma, Tejbir S. Buttar and Vivak M. Arya

Division of Soil Science and Agriculture Chemistry, FoA, SKUAST-Jammu

Soil erosion presents a global threat to sustainability of agricultural production systems. The foothill Shivaliks face an acute problem of soil erosion owing to topography and rainfall pattern. This is further aggravated by poor management practices. A study was undertaken in the erosion prone *kandi* area of Jammu to assess the influence of conservation agricultural practices (CAP) on losses of soil carbon through eroded sediments and runoff under maize crop. Three tillage variations i.e. conventional tillage (CT), minimum tillage (MT) and zero tillage (ZT) were employed, and were combined with management practices such as intercropping (i), mulching (m) and residue retention (30%) (r). Runoff and the sediments collected during major rainfall events were analyzed for carbon and the amount of C lost was quantified based upon total runoff and soil loss. The loss of OC concentration occurring at various runoff events ranged from 3.60 (ZTm) to 11.97 (MT) mg l^{-1}. The total cumulative C loss in runoff ranged from 3.72 kg ha^{-1} (ZTm) to 7.13 kg ha^{-1} (MT) among the treatments. The total loss through sediments that had occurred up to the end of growing season ranged from 10.25 kg ha^{-1} (ZTm) to as high as 48.31 kg ha^{-1} (CT). The results revealed that total amount of organic carbon loss in runoff water was maximum in MT while the minimum amount of C loss was in ZTm. The application of residue or mulches or intercropping with pulses effectively reduced the C loss mainly because of the reduction of runoff under these treatments while the maximum amount of sediment loss occurred in CT as tillage played significant role in accelerating soil C loss through oxidation of organic matter and destruction of soil aggregates leading to significant water erosion and surface runoff of C-rich sediments.

Key words: *Erosion, Carbon, Conservation agriculture, Tillage*

2

EFFECT OF DIFFERENT RESOURCE CONSERVATION TECHNIQUES ON WATER QUALITY OF ADOPTED PONDS IN LOWER SHIVALIKS OF NORTH - WESTERN HIMALAYAS

Vivak M. Arya, Vikas Sharma and Ajay Thakur

Division of Soil Science and Agriculture Chemistry, FoA, SKUAST-Jammu
Corresponding author email: dr.arya999@gmail.com

The water resource in the lower Shivalik region of Jammu is facing daunting challenges due to urbanization, industrialization and huge demand for agricultural activities. The potential for augmentation of water availability is limited, water tables are receding day by day and water quality issues have been increased. Mere 25 % plain area is covered under different canal command areas, whereas 75% is rainfed spread over ten districts of Jammu region. The study was conducted to assess the impact of water conservation modules on water quality of four adopted ponds at village Merth, Sahar and Uttri of district Kathua respectively. The participatory rural appraisal report of each village has been formulated to understand location as well as present resource potential of the district. The adopted ponds have been redesigned in such a manner that most part of the runoff from adjoining rivulets can be tapped in the ponds. The methodology to assess the impact of RCTs for improving the water & soil

quality of ponds are Digital Elevation Model (DEM) mapping of watershed area, bunding, contour bunding, promoting terrace farming, diversion of sewage water, constructing channels to divert rain water into ponds and promoting rain water harvesting. Various physico-chemical and biological parameters were assessed using standard procedures before and after adopting resource conservation techniques. The water parameters which were assessed are pH, dissolved oxygen (DO), biological oxygen demand (BOD), electrical conductivity (EC), temperature, turbidity, total coli forms, nitrate & total dissolved solids (TDS). The overall Water Quality Index (WQI) value on the scale of 0-100 for the four adopted village ponds before adopting conservation module was 50.0 (Medium) for Merth first pond, 21.0 (Very Bad) for Merth second pond, 42.0 (Bad) for Sahar pond and 40.0 (Bad) for Uttri pond. After adopting conservation modules the WQI value of adopted village ponds was 78.0 (Good) for Merth first pond, 52.0 (Good) for Merth second pond, 74.0 (Good) for Sahar pond and 72.0 (Good) for Uttri pond. The study thus revealed that there is an improvement in water quality of adopted ponds and which can be further improved by sustaining these conservation modules. The trainings and awareness given to farmers and local residents of village also played an important role as they will help in participatory approach for the conservation of these ponds.

Key words: *Water Quality Index, Digital Elevation Model. Conservation modules, Ponds*

3

LINEAR STATISTICAL DOWNSCALING FOR RAINFALL FORECASTING OVER GUJARAT

Kanhu Charan Panda and R. M. Singh

Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (UP)
Corresponding Author email:kanhucharan.bm@gmail.com

In this work linear downscaling model is used to establish empirical relationships between the synoptic-scale circulation and observed rainfall over Gujarat state of India. The methodology uses outputs from the regional Eta Model; prognostic equations for local forecasting were developed using multiple linear regression (MLR). The final objective is the application of such prognostic equations to Eta Model output to generate rainfall forecasts. In the first experiment the predictors were obtained from the Eta Model and the predictand was rainfall data from meteorological stations in Gujarat. In the second experiment the observed rainfall on the day prior to the forecast was included as a predictor. The threat score (TS) and bias, used to quantify the performance of the forecasts, showed that the MLR performance is good in most seasons. When the observed rainfall of the previous day is included as a predictor, the TS showed the best performance in continuous rain and well-organized meteorological systems. The obtained results also suggest that in the austral winter rainfall is more predictable because convection is less frequent, and when this occurs the forcing is dynamic instead of thermodynamic.

Key words: *Climate change, Statistical downscaling, Threat score, Gujarat and predictor*

4

APPLICATION OF ARTIFICIAL NEURAL NETWORK FOR FORECASTING SEASONAL GROUNDWATER DEPTH

Kusum Pandey

Ph.D. Research Scholar, Punjab Agricultural University, Ludhiana, Punjab
Corresponding Author email: khushipandey166@gmail.com

Forecasting of groundwater level variations is a significantly needed in groundwater resource management. Precise water level prediction assists in practical and optimal usage of water resources. Therefore, in the present study, 18 models have been developed by using artificial neural neural with the help of Levenberg- Marquardt technique to predict the seasonal groundwater level in the area between the Ganga and Hindon rivers in Uttar Pradesh, India.The architecture of ANN was designed with hyperbolic tangent activation function and Delta-Bar-Delta learning algorithm by MATLAB 2016 software. These models were developed by using 21 years (1994-2014) data, employing net recharge, net discharge and the past ground water level as input and the present groundwater level as output. The predictive ability of the models was evaluated by using eight performance indicators such as coefficient of determination (R^2), Coefficient of efficiency (CE), Correlation coefficient (r), Mean absolute deviation (MAD), Root mean square error (RMSE), Coefficient of variation of error residuals (CVRE), Absolute prediction error (APE) and Performance Index (PI). The result indicates that the developed models can successfully be used for prediction of ground water level and model 8 was found to be best to predict the depth to water table during both the seasons. It was also found that more number of input parameters in the model improved the accuracy of forecasting of the model by using artificial neural technique.

Key words: *Artificial neural network, Groundwater, Performance indicators, Forecasting*

5

ENVIRONMENTAL BIOMES

Deeksha Saxena

Department of Environmental Science, Bareilly College Bareilly
Corresponding author email: saxenabadki440@gmail.com

A community of different species of plants, animals, and fungi, have evolved to coexist in a specific climate and landscape. Terrestrial biomes are usually defined by the type of vegetation that is present. The coldest biome is called the tundra, located at the North (Arctic) and South (Antarctic) Poles. Plants that grow in the tundra include lichen, short shrubs, sedges, grasses, flowers, birch trees and willow trees. Their short height makes them less vulnerable to strong tundra winds, and shallow roots allow them to pull moisture from the soil above the permafrost. A warmer climate could naturally change tundra region. Air pollution affects tundra environments. Black carbon from diesel engines, fires, and other combustion can settle on snow, decreasing its ability to reflect sunlight and causing faster melting. The largest terrestrial biome on Earth is called the Taiga. It is found south of the Arctic tundra. It is cold and snowy. The vegetation consists mostly of coniferous evergreen trees. Coniferous trees are those that have needle-like leaves. Some of the conifer species are pine (Pinus), spruce (Picea), larch (Larix) and fir (Abies). Direct human activity and climate change are affecting taiga's environment. Warming climate contributes to a partial defrosting. Tropical rainforests make up one of Earth's largest biomes dominated by broad-leaved trees that form a dense upper canopy. The rainfall can reach up to 400 inches in one

year. Orchids grow in the tropical rainforest. The rise in temperature leads to the reduction in rainfall. As temperatures increase, forest fires also increases. CI scientists have identified three zones to make zero net deforestation- Green Zone: protected areas or indigenous lands and territories. Yellow Zone: Mostly forested land that has not yet been formally protected or developed. Red Zone: Land that has already been converted to agriculture developed into cities or otherwise degraded by human activities. The grassland biome includes terrestrial habitats that are dominated by grasses and have relatively few large trees or shrubs. Grassland has Semi-arid climate. Rainfall and soils insufficient to support significant tree growth in grassland biome. Grasslands are often exploited for agricultural use. Deserts cover more than one-fifth of the Earth's land area, found on every continent. Semi-arid regions are turning into desert. Desertification is not caused by drought, but arises from deforestation and the demands of human populations that settle on the semi-arid lands.

Key words: *Biome, Climate change, Plants, Species*

6

STUDIES ON INM IN MAIZE (*Zea mays* L.) IN UPPER GANGETIC PLAINS REGION

Gyanendra Kumar[1*] and Himanshu[2]

[1]Department of Agronomy, Sardar Vallabh Bhai Patel University of Agriculture &
[3]Department of Agronomy, Bundelkhand University Jhansi-284128 (UP) India
**Corresponding Author email: gyanendrapaswan786@gmail.com*

Considering the effect of green revolution technologies in rice-wheat system and prospects of maize cultivation, studies on INM in maize (*Zea mays*. L) in upper gangetic plains region were conducted on sandy loam soil, low in organic carbon and available N, medium available P and K with 9.1 kg S ha^{-1}, 0.82 g Zn ha^{-1}, 0.6 g B ha^{-1} and slightly alkaline in reaction during *kharif* 2015 at SVPUAT, Meerut to observe the effect of nutrient management practices on growth, yield, quality, nutrient content and uptake, monetary returns and residual soil fertility. The treatments comprising of inorganic fertilizers, FYM, biofertilizers and micronutrients {Control, 100% NPK (150:60:40), 75% NPK + FYM @ 7.5 t, 100% NPK + Zn, 100% NPK + B, 100% NPK + S, 100% NPK + Zn + B + S, 75% NPK + FYM @ 7.5 t + Zn + B +S, 100% NPK + *Azotobacter*,100% NPK + PSB, 100% NPK + *Azotobacter*+ PSB and 75% NPK + FYM @ 7.5 t + *Azotobacter* + PSB} were tested in RBD with 3 replications. Maize hybrid Pioneer-3377 sown on 25th July 2015 were grown with recommended package except the treatments and harvested on 22nd October 2015. Growth, yield attributes and yield were significantly affected by nutrient management practices. Application of Zn, B, S, Zn + B + S, *Azotobacter*, PSB, *Azotobacter* + PSB along with 100% NPK favored growth, yield attributes and yield when compared with 100% NPK. Respective increase in grain yield was12.5,7.3,7.3,13.5,7.1,6.1,8.3 and 15.9 % over 100% NPK. Crop fertilized with 75% NPK + FYM @ 7.5 t + Zn + B +S registered best growth and consequently highest (48.8 q ha^{-1}) grain yield and attributes. Application of Zn, B, S, Zn + B + S along with 100% NPK led to an increase in nutrient content in plant tissues and therefore higher uptake of N,P,K,S,Zn and B. Contents of N,P,K,Zn and B in grains ranged from 1.23 to 1.74, 0.19 to 0.37, 0.25 to 0.44, 0.18 to 0.36 %, 0.31 to 0.62 and 0.34 to 0.65 ppm, respectively, lowest being with no fertilizer and highest with 75% NPK + FYM @ 7.5 t + Zn + B +S. Respective ranges of uptake were 41.0-128.6 kg ha^{-1}(N), 8.5-32.0 kg ha^{-1}(P), 53.1-133.4 kg ha^{-1}(K), 12.2-45.1 kg ha^{-1}(S), 19.2-90.4 g ha^{-1}(Zn) and 22.3-90.4 g ha^{-1}(B). In general, grains accumulated more N and P than stover. A reverse pattern was observed in respect of K, S, Zn and B having beenhigher in stover. Crop cultivation without fertilizer application resulted in negative nutrient balance in soil whereas application of nutrients had a favorable effect on nutrient replenishment. Crop grown with 75% NPK + FYM @ 7.5 t + Zn + B +S

fetched highest gross (₹85225 ha^{-1}) and net returns (55730 ha^{-1}) with highest B:C ratio (2.89) followed by100% NPK + Zn, 100% NPK + *Azotobacter* + PSB, 100% NPK + *Azotobacter* and 75% NPK + FYM @ 7.5 t.

Key words: *Growth, Yield, Quality, Nutrient content, uptake, Monetary returns and Residual soil fertility*

7

CONSERVATION OF SOIL AND WATER AROUND THE WORLD: STRATEGIES AND RESEARCH CHALLENGES

Vijeta Singh

Department of Soil and Water conservation Engineering
Vaugh Institute of Agricultural Engineering and Technology
Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (Prayagraj), Uttar Pradesh

The world population is growing at a great pace. It is estimated that the population will soon find billions. This will certainly create a serious need for food in the future. Larger land resources were needed to supply food to the growing population, and soils were put under intensive use for overproduction. On the other hand, as a result of the pressure of increasing population, the deterioration in the fertile soil resources and the result of the structuralization show the effects of the loss of the area. As a result of the increase in the need for land resources, many countries around the world need to map their land in detail and use the land according to their capabilities. When the sustainability of natural resources is mentioned, first of all, soil erosion and its negative effects on the environment are one of the first issues that come to mind. Under normal conditions, climate, soil, topography and vegetation are the main elements that complement each other.

Soil erosion is the result of this interaction. It is clear that the risk of erosion in agricultural areas is high, and if the conservation measures required by sustainable agricultural techniques are not taken, it will be possible to reach irreversible levels. Moreover, our resources, which are already limited by accelerated soil erosion, may be under great threat in the future. Water and water resources should be protected as in life; it needs absolute water in agriculture. In arid regions, the best way to protect water is to grow plants that are suitable for the ecology of the region or that only need water during rainy season. Green manure and mulch are useful in keeping water in soil. The contour barriers protect the water by preventing the water flow. Another method for preserving water is to apply drip (Trickle) irrigation instead of traditional irrigation methods and to make irrigation time planning. We can also use alternative options of farming instead of traditional crop production such as soilless culture. Which serve the purpose of soil and water conservation both at a time.

Key words: *Drip (Trickle) irrigation, Soil erosion, Water resources, Irrigation time planning.*

8

INTEGRATED FARMING SYSTEMS FOR ENHANCING TRIBAL FARMERS' INCOME IN NORTH-EASTERN HILL REGION OF INDIA

Sanjay-Swami*

School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Umiam (Barapani) - 793 103, Meghalaya, India

**Corresponding author email: sanjayswamionline@gmail.com*

North-East Hill Region (NEHR) accounted 8.0 per cent of the total area and 3.4 per cent of total cultivable area of India. However, the region contributes only 2.8 per cent to the total food grain production of the nation. Majority of the fields in the region are situated across the hilly slopes. Nearly 0.88 m ha area in NEHR is under *Jhum* cultivation. The region, by and large, is characterized by fragility, marginality, inaccessibility, culturally heterogeneity, ethnicity, however it is endowed with a rich repository of biological diversity, valuable genetic resources of agricultural crops and a plethora of natural resources. The production system is characterized by low cropping intensity, subsistence level and mono-cropped as almost 80 percent of the cultivated land is under rice cultivation only. Though more than 70 per cent of the total population (41million) depends entirely on agriculture, rarely they generate surplus income after meeting their daily requirements. As a result, the stamp of backwardness has been attached to this region.

Integrated farming system approach is not only a reliable way of obtaining fairly high productivity with considerable scope for resource recycling, but also a concept of ecological soundness leading to enhanced livelihood. Central Agricultural University, Imphal has developed several farming system models for each fragile hill agro-ecosystem based on different monitorable variables involving fish culture, livestock, crops and agro-forestry to meet the challenge of doubling tribal farmers' income in the region. These models are assessed on the basis of capability to sustain the farm family needs, food and nutritional requirement of one family having 5 adult members. The packages of practices for different location specific farming systems have been developed and verified extensively for economic viability and feasibility at the farmers' level. It can be concluded that the location specific farming components are required to be intelligently identified to harness complementarities between enterprises to achieve optimum productivity from unit area, ensuring food and nutritional security and getting higher returns and bio-resource flow within the system. IFS can be a powerful tool to double farmers' income and improve their lives.

Key words: *North Eastern hill region, IFS, Location specific, Doubling tribal farmers' income*

9

HYDROGEL IN AGRICULTURE TECHNOLOGY FOR INCREASING WATER HOLDING CAPACITY OF SOIL

Sonal Baria[1], B.B. Limbasiya[2] and Naresh Damor[3]

[1]Senior Research Assistant, Polytechnic in Agricultural Engineering, JAU, Targhadia-Rajkot, [2]Assistant Professor, Polytechnic in Agricultural Engineering, Junagadh Agricultural University Targhadia – Rajkot, [3]Students of College of Agriculture, Junagadh Agricultural University, Mota Bhandariya –Amreli

In the last decade, one of the problems affecting the environment has been the increased use of plastic materials and their subsequent disposal. Plastics have been used in innumerable applications with little consideration for their ultimate disposability. Smart polymeric materials and smart delivery systems helped the agricultural industry to combat viruses and other crop pathogens, functionalized polymers were used to increase the efficiency of pesticides and herbicides, allowing lower doses to be used and to indirectly protect the environment. The solutions through hydrogen bonding with water molecules is hydrogel. Agricultural hydrogel are referred to as water retention granules because they swell to many times their original size when they come in contact with water. It has been widely proposed over the last 40 years for agricultural use with the aim to ameliorate water availability for plants, by increasing water holding properties of growing media (soils or soilless substrates). Most of the area of India is located in arid and semiarid regions, more efficient use of water is essential in the field of agriculture. Implementing proper management practices in agriculture to maintain soil moisture and increase water holding capacity is considered as one of the ways to save water. Super absorbent polymers (SAPs) hydrogel can swell to absorb huge volume of water or aqueous solution. This property has lead to many practical applications of these new materials in particularly in agriculture for improving water retention of soils and the water supply of plants. The relative effectiveness of the hydrogel depends upon chemical properties of the hydrogel, such as molecular weight, and the hydrogel properties tend to have differing effects on various soil properties.

Key words: *Smart Materials, Hydrogel, SAPs, Water Holding Capacity*

10

INCIPIENT MOTION OF SOLITARY SEDIMENT PARTICLES OVER ROUGH BEDS

Anuradha Kumari* and Akhilesh Kumar

Department of Soil and Water Conservation Engineering, G.B.P.U.A.&T, Pantnagar, Uttarakhand-263145, India
**Corresponding Author email: anuradhakhushio7@gmail.com*

Bedload sediment transport is very important in the analysis of river morphology. One of the most fundamental and practical issues in bed load transport is making predictions on initial sediment motion. The incipient motion of sediment particles depends on flow sediment and channel characteristics. Channel characteristics i.e bed roughness is changed in this study to know the effect of channel bed roughness on incipient motion of solitary particles. Majority of study conducted on movable bed only few researches were concerned with fixed beds. In this study, three different sizes of gravel particles were glued to raxin sheets to simulate three different bed roughnesses. The findings of the study have been illustrated with mathematical relationships and graphical representations for various combinations of input variables.

Key words: *Rough bed, Sediment transport, Particle Size, Critical Shear Stress, Incipient motion*

11

PERFORMANCE OF SALT TOLERANT VARIETIES OF RICE IN SODIC SOILS OF AURAIYA DISTRICT

S. K. Singh[1*], Chandan Singh[1], Ankur Jha[2] and Anant Kumar[1]

[1]Krishi Vigyan Kendra (KVK), Auraiya, Uttar Pradesh (206244)
[2]ICAR- ATARI, Zone-III, Kanpur Uttar Pradesh
**Corresponding Author email: sandipsingh11@rediffmail.com, nicechandansingh@gmail.com*

Rice (*Oriza sativa* L.) is one of the important cereal crops in India, Uttar Pradesh is one of the major rice producer having about 59.66 lakhs ha area under rice and producing about 143.96 lakh tonnes with an average productivity of 24.13 q/ha. Of the total rice cultivated area in Uttar Pradesh, Auraiya district in Western Uttar Pradesh is having about 49819.84 ha area under rice with an average productivity of 30.87 q/ha. Of the total rice cultivated area in Auraiya district, about 29.2% area is affected with sodicity having average soil pH 8.4. The ground water quality in the district is also poor having pH up to 9.1. Due to this twin stress problem, the productivity of rice is very low (20 q/ha). Front Line Demonstrations were conducted on 70 farmers' fields in 6 villages on 70 acre sodic land in *kharif* season during 2016, 2017 & 2019 to evaluate the comparative performances of local (Kranti) and salt tolerant variety (CSR 36) of rice. The results revealed that the salt tolerant variety CSR 36 produced significantly higher grain yield (58.18 q/ha) than the local variety Kranti (53.8 q/ha). The cost economics calculated for cultivation of local and salt tolerant variety shows that the net return of salt tolerant variety (Rs. 31410) was 17.70% higher than the net return of Rs. 26685 from local variety (Kranti). Similarly, B:C ratio with salt tolerant variety CSR 36 (1:2.0) was also higher than that of local variety. Based on crop yield, cost economics and B:C ratio, CSR-36 was giving better results in comparison to local variety Kranti in the year 2016. In the year 2017 CSR 36 yielded 58.8 q/ha whereas, the local variety yielded 53.4 q/ha. The net return of CSR 36 and Kranti was Rs. 45486 and Rs. 38420/ha respectively. The B:C ratio CSR-36 (2.47) was also higher than the local variety (2.24). In year 2019 salt tolerant variety (CSR 36) yielded 59.7q/ha whereas, the local variety yielded 50.6 q/ha. with the net return of Rs. 48094 and Rs. 34700 respectively. Based on three years study, it is concluded that the salt tolerant variety CSR 36 is giving better result in comparison to local variety Kranti. With the introduction of CSR 36, in the study area, the productivity of rice has increased by 8-10%.

Key words: *Rice, Salt tolerant varieties, Sodic soils, Grain yield*

12

WEED MANAGEMENT UNDER DIFFERENT RICE RESIDUE MANAGEMENT OPTIONS IN WHEAT

N. K. Singh[1], A. K. Srivastva[2] and Y. P. Singh[3]

[1]Scientist (Agronomy), Krishi Vigyan Kendra, Pratapgarh
[2] Senior Scientist & Head, Krishi Vigyan Kendra, Pratapgarh
[3]Principle Scientist (Agronomy), ICAR-CSSRI, Regional Research Station, Lucknow

It has been estimated that in India nearly 57% of the total geographical area is affected by land degradation. Land productivity due to increasing land degradation is decreasing day by day. In the present era of globalization, it is important to reduce the cost of cultivation to make the farm produce more competitive and profitable. One of the area where cost can be reduced, is the expenditure on chemical fertilizers and tillage. Large quantity of rice residues are left on the soil surface, especially

where combines are used for crop harvest. Burning of residues in the field can result in up to 80% loss of tissue nitrogen by volatilization besides it is a significant source of air pollution. Retaining crop residues on the surface, rather than burning them or incorporating them by tillage, increase organic carbon and total soil nitrogen in the top soil. Crop residues may provide weed suppression through their physical presence on the soil surface as mulch. Rice residue management can influence weed dynamics and productivity of wheat crop. In view of the above , a field experiment was conducted at KVK, Pratapgarh during *Rabi* 2017-18 and 2018-19 to evaluate the influence of two broad spectrum post-emergence herbicides (Isoproturon + Carfentrazone and Iodo + Mesosulfuron) in wheat for weeds under different rice residue management options (residue incorporation, residue burning and zero tillage). Residue management options were assigned to the experimental fields while weed control treatments were maintained in farmer's fields. The results revealed that, zero tillage was helpful in averting weed growth and recorded more wheat grain yield even under no weed management practice as compared to the other residue management options. Residue incorporation resulted higher weed density and biomass than residue burning. Both the herbicides provided >70 percent suppression in weed density and dry biomass with upper limit 90 percent recorded when Isoproturon + Carfentrazone was applied to zero tillage plots. The herbicide treatments also improved wheat leaf area indices, crop growth and dry matter accumulation over no weed management practice under all residue management options. Maximum grain yield (38.2 q/ha) was obtained when Isoproturon + Carfentrazone was applied to zero tillage plots. Highest economic net benefits were also associated with the same treatment combination. Zero tillage seems more appropriate residue disposal method in Rice – wheat cropping system than residue burning and incorporation.

Key words: *Herbicide, Residue, Rice residues, Weed, Wheat yield, Zero tillage*

13

EFFECT OF LASER LAND LEVELLING ON YIELD OF WHEAT AND WATER SAVING

A. K. Srivastva[1] and N. K. Singh[2]

[1] *Head/Senior Scientist, Krishi Vigyan Kendra, Pratapgarh*
[2]*Scientist-Agronomy, Krishi Vigyan Kendra, Pratapgarh*

Levelling has been practiced throughout the world for more than half a century. It involves preparing, modifying, or reshaping the land surface to a planned grade for providing a suitable surface for crop cultivation. This way, the process of land levelling provides suitable surface to control the flow of irrigation water, minimizing soil loss by checking soil erosion and facilitate better surface drainage. Traditionally farmers level their fields using animal drawn or tractor-drawn levellers. However, even the best-levelled fields using traditional land levelling practices are not precisely levelled and this leads to uneven surface which requires frequent levelling operations during land preparation. Recognizing these limitations, a field study was conducted in *Rabi* seasons during 2015-16 and 2016-17at village Chhachhamau in district Pratapgarh on a silty-clay soil with an objective to find out the effect of laser land levelling on yield of wheat crop (Var. KRL-210) and water saving. Treatments comprising of farmer's practice (FP) *i.e.* field with traditional level and laser levelled fields with imposition of 0.05, 0.15 and 0.30% slopes in large plots. Average grain yields of wheat under laser and traditionally levelled field conditions were 36.5 and 29.75 q/ha, respectively which was 18.5 percent higher over farmer's practice and was significantly higher. Similarly, straw yield was significantly higher with laser levelled field than the traditionally levelled fields. The results indicated that laser levelling reduced irrigation time by 4.20 hours/ha and saved about 5.45 ha-cm irrigation water over the traditional practices. Among the slopes evaluated in

the study, 0.15% slope was adjudicated superior over 0.5 and 0.30%. Thus, there is an urgent need to promote the concept of precision levelling of agricultural fields amongst farmers as an endeavour to save water and energy used for practicing irrigation as well as providing favourable environment for crop growth. Cost economics of the study showed an additional income of Rs. 10550/ha due to additional grain and straw yields with adoption of laser leveller.

Key words: *Laser land levelling, Slope, wheat yield, Irrigation water saving*

14

EFFECT OF ZERO TILLAGE, RICE RESIDUE AND NITROGEN MANAGEMENT ON GRAIN YIELD OF WHEAT IN RICE-WHEAT CROPPING SYSTEM

N. K. Singh[1], A. K. Srivastva[2] and Y. P. Singh[3]

[1]*Scientist-Agronomy, Krishi Vigyan Kendra, Pratapgarh*
[2] *Head/Senior Scientist, Krishi Vigyan Kendra, Pratapgarh*
[3]*Principle Scientist-Agronomy, RRS-CSSRI, Lucknow*

Rice-wheat rotation is a major production system in India. Farmers generally use wheat straw as animal feed but rice straw is either burned in the field or used as mulch for moisture retention. However, burning produces greenhouse gases, which are hazardous to our environment and also affect human health. It destroys our precious natural resource (the organic matter) that may adversely affect soil physical, chemical and biological properties. Besides these harmful effects, burning results in nutrients losses and decreases soil microbial activities. Burning of huge amount of rice residue is not only a waste of organic manure source but also negatively affects soil ecosystem. Residue retention/ incorporation into soil is an essential management practice to handle crop residue. ZT with residue retention increases soil organic matter and total soil N and therefore induces major changes in N management. ZT may out yield all other tillage methods if N management is optimized. Zero tillage with residue retention and optimizing nitrogen fertilization are important strategies to improve soil quality and wheat yield in rice-wheat system. Based on the above hypothesis, field trials were conducted on silty clay soil in district Pratapgarh, Uttar Pradesh to explore the impact of zero tillage straw retained (ZTsr), ZT straw burnt (ZTsb), Reduced tillage straw incorporated (RTsi, including tiller and rotavator), Reduced tillage straw burnt (RTsb), Conventional tillage straw incorporated (CTsi, together with tiller, rotavator, and levelling operations), Conventional tillage straw burnt (CTsb) with four nitrogen levels i.e. 100, 120, 150 and 200 kg/ha. Mean values for tillage operations revealed that ZTsr produced highest number of tillers per sq m among tillage methods. However, grains per spike, 1000-grain weight, and grain yield were higher in tillage methods with either straw retained/ incorporated than tillage methods with straw burnt. ZTsr produced the maximum tillers per sq m and 1000-grain weight at 200 kg N per ha. ZTsr also produced higher soil organic matter and total Nitrogen at 200-250 kg N per ha at the end of 2nd year cropping. Thus, ZTsr with 200 kg N per ha may be an optimum and sustainable approach to enhance wheat yield and soil quality in rice-wheat system.

Key words: *Wheat yield, Zero tillage (ZT), Nitrogen levels, Conventional tillage (CT), Soil organic matter*

15

EFFECT OF SULPHUR LEVELS ON GROWTH, YIELD ATTRIBUTES, YIELD AND QUALITY OF INDIAN MUSTARD [*Brassica juncea* (L.) CZERN AND COSS] VARIETIES

Jyoti Verma[1], Ravindra Kumar Rajput[2], Pradeep Rajput[3], Anupama Verma[4] and Ambreesh Singh Yadav[5]

[1]Department of Agronomy, School of Agriculture, Sanskriti Universuty Chhata, Mathura (U.P.),[2]Subject Matter Specialist, Soil Science, KVK Mathura,[3]Research Scholar, Agronomy, SVBPU&T Modipuram, Meerut,[4]PG Student, Plant Physiology, CSAU&T, Kanpur,[5]Scientist Officer at UPCAR, Lucknow

A field experiment was conducted at the Farmers' field Village - Bati, Block – Mathura, District – Mathura, (UP) during *rabi* season of 2017-2018. The experiment was laid out in RBD having twelve treatments replicated four times, Treatment combinations consisted of three mustard varieties (V_1- Kranti, V_2- RH-749 and V_3- Maya) and four sulphur levels (S_0- 0, S_1-20, S_2-40 and S_3-60 kg ha^{-1}). The soil of the experimental farmer's field was silty loam in texture with low organic carbon (0.35%) and nitrogen (211.60 kg ha^{-1}) and medium in phosphorus (16.20 kg ha^{-1}) and potassium (209.0 kg ha^{-1}). The Mustard varieties were sown at 3.0 kg ha^{-1} in lines 45 cm apart and 4-5 cm deep with seed drill on 23 October, 2017. Application of 60 kg S ha^{-1} recorded higher plant height (cm), maximum leaf area index, number of branches plant^{-1}, and dry matter accumulation at all the growth stages (30, 60, 90 and at harvest stages) which was at par with 40 kg S ha^{-1} and significantly superior over the rest of treatments. In case of varieties all the growth characters were significantly better in RH-749 over the rest of mustard varieties. The maximum number of siliqua plant^{-1} (303.68) and maximum length of siliqua (6.80 cm) were observed with 60 kg S ha^{-1}. The maximum number of seeds siliqua^{-1} (13.78) was also recorded with 60 kg S ha^{-1} however, it was significantly superior over remaining doses of sulphur. The test weight (4.41 g) of mustard increased with increase in dose of sulphur up to 60 kg ha^{-1}. In case of varieties the yield attributes were significantly superior in RH-749 as maximum number of siliqua plant^{-1} (297.96) and maximum length of siliqua (6.68cm), number of seeds siliqua^{-1} (13.47) were recorded. The Stover yield (66.15 q/ha), and seed yield (25.71 q/ha) of mustard were significantly increased with increasing dose of sulphur up to 60 kg S ha^{-1} which was at par with 40 kg S ha^{-1} and significantly superior over 0 and 20 kg S ha^{-1}.The variety RH-749 produced higher value of stover yield (64.67), seed yield (25.07) which was significantly higher over that of Kranti and Maya. The higher oil and protein content in seed was recorded with the application of 60 kg S ha^{-1} which was significantly superior over control and at par with 40 kg S ha^{-1}. A common cost of cultivation of Rs 21644.88 was computed with the treatment combinations of S_{60} + V_1, S_{60} + V_2 and S_{60} + V_3, which was higher than other combinations.

Key words: *Sulphur levels, Growth, Yield, Quality, Indian mustard*

16

MANAGEMENT OF SOIL AND WATER RESOURCES FOR SUSTAINABLE CROP PRODUCTION

Yuvraj Singh*

Department of Environmental Sciences, Kamla Nehru Institute of Physical and Social Science, Sultanpur-228132, Uttar Pradesh, India

**Corresponding author email: yuvrajj1997@gmail.com*

The rising population and reduction in the amount of land and some other resources have created tremendous pressure on current agricultural producers to meet the increasing food demands. To cope with this challenge, certain key inputs, such as fertilizers and other chemicals, are overused, which are worsening the surroundings. This intensive agricultural production without adherence to ecological sustainability has led to declining soil health, land degradation, and severe environmental problems. So, future efforts to feed the growing population should aim for greater agricultural production within sustainable environments. In this regard, innovative steps are needed, as business-as-usual policies lack the potential to cope with these challenges. The concept of agricultural sustainability and various soil and crop management strategies (SCMS) that have been designed to optimize crop yield under sustainable environmental conditions are discussed, including nutrient management. The state of Punjab comprising 1.5% area of the country has been contributing 40-50% rice and 60-65% wheat to the central pool since last three decades. During last 35 years the area under food grains has increased from 39,200 sq km to 63,400 sq km and the production of rice and wheat has increased from 0.18 to 0.32 kg/m^2 and 0.22 to 0.43 kg/m^2 respectively. This change in cropping pattern has increased irrigation water requirement tremendously and the irrigated area has increased from 71 to 95% in the state. Also the number of tube wells has increased from 0.192 to 1.165 million in the last 35 years. The excessive indiscriminate exploitation of ground water has created a declining water table situation in the state. The problem is most critical in central Punjab. The average rate of decline over the last few years has been 55 cm per year. The worst affected districts are Moga, Sangrur, Nawanshahar, Ludhiana and Jalandhar. This has resulted in extra power consumption, affects the socio-economic conditions of the small farmers, destroy the ecological balance and adversely affect the sustainable agricultural production and economy of the state. Therefore, in this paper attempt has been made to analyse the problem of declining water table, possible factors responsible for this and suggest suitable strategies for arresting declining water table for sustainable agriculture in Punjab. The strategies include shift of cropping pattern, delay in paddy transplantation, precision irrigation and rainwater harvesting for artificial groundwater recharging.

Key words: *Land degradation, Arresting, Adherence, Exploitation*

17

INFLUENCE OF CROP ESTABLISHMENT AND NITROGEN LEVELS ON GREENHOUSE GAS EMISSION IN DIRECT SEEDED RICE

Veena Bharati[1], Suborna Roy Choudhury[1], Vivek Kumar[2] and Shraddha Mohanty[3]

[1]Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar-813210, India,[2]Department of Horticulture, Bihar Agricultural University, Sabour, Bhagalpur, Bihar-813210, India,[3]Department of soil science and agricultural chemistry, OUAT, Bhubaneswar-750017

Corresponding author email: veenabharati50@gmail.com

Climate change is the principal modern day environmental issue and is mainly caused by increasing concentration of greenhouse gasses in atmosphere. Different agricultural activities are linked with the emission of greenhouse gases mostly methane and nitrous oxide. To study the same a field experiment was conducted at research farm, Bihar Agricultural University, Sabour India during 2017 and 2018. The experiment was conducted in split plot design with two tillage viz. zero tillage (ZT) and conventional tillage (CT) as main plot and four nitrogen management practices viz. 100% nitrogen through neem coated urea (S_1), SPAD based nitrogen management (S_2), 75% through neem coated urea + 25% nitrogen through vermicompost, (S_3) and ¼ nitrogen as basal and rest in equal three splits at 20, 40, 60 DAS (S_4) as sub plot, in three replication. The range of methane (0.57- 1.47 mg m^{-2} hr^{-1}) and nitrous oxide (19.58-38.79 µg m^{-2} hr^{-1}) emission was recorded lowest in zero tilled plots and split application of nitrogenous fertilizer also emitted lowest values of 1.59 mg m^{-2} hr^{-1} methane and 46.76 µg m^{-2} hr^{-1} nitrous oxide at maximum tillering stage of crop growth. Moreover, methane and nitrous oxide emission gradually decreased from maximum tillering to harvesting stage. Zero tilled DSR with split nitrogen fertilizer application attributed lowest greenhouse gas intensity among the other crop establishment and nitrogen management options. Therefore, zero tilled method of crop establishment with split application of nitrogenous fertilizer could be a remunerative and environmentally stable method for direct seeded rice cultivation.

Key words: *Conventional tillage, Greenhouse gas, Split application, Zero tillage*

18

BIODIVERSITY CONSERVATION

Prateeksha Saxena*

Department of botany, Suraj Bhan Institute of Information Technology, Bareilly (UP)

**Corresponding Author email: saxena.prateeksha1999@gmail.com*

The biodiversity is the variety of life on Earth at all its levels. Biodiversity includes species we consider rare, threatened, or endangered and every living thing; from humans to organisms we know little about, such as microbes, fungi, and invertebrates. Biodiversity is important to most aspects of our lives. We value biodiversity for many reasons, some utilitarian, and some intrinsic. This means we value biodiversity both for what it provides to humans, and for the value it has in its own right. Over the last century, humans have come to dominate the planet, causing rapid ecosystem change and massive loss of biodiversity across the planet. Major direct threats to biodiversity include habitat loss and fragmentation, unsustainable resource use, invasive species, pollution, and global climate change. Humans cutting down precious forests for agriculture, fuel or to build houses. In many cases the production and release of wastes acting as pollutants have completely destroyed the habitat of many species. The habitat areas in most cases have got shrunk due to many reasons and stand as isolated patches or islands. Not enough water for

certain species to survive. Poisonous gases in the air causing respiratory problems in many species. Plastics, oil and other water contaminants making it difficult for fish and sea birds to thrive in our rivers, lakes and oceans. Research the plants and vegetables that are local to your area and grow a variety. Each plant and vegetable helps to protect biodiversity and supports the wider ecosystem of your local area. Fresh bodies of water are essential to biodiversity. Reducing the amount of water you use, by having a 5-minute shower or not running the water when washing up the dishes, can help protect vital wetlands. Recycling lessens pollution by decreasing energy, electricity, and water consumption and the need for landfills. Buying from your local farmer at a farmers' market or through a farm stand gives you the ability to find out how your food was grown and learn what they are doing on the farm to help conserve biodiversity.

Key words: *Biodiversity conservation, water, wetlands, forests*

19

GREEN ENERGY

Richa Saxena*

Department of Environment Science, Bareilly College Bareilly
**Corresponding author email: richasaxena442@gmail.com*

Green energy comes from natural sources such as sunlight, wind, rain, tides, plants, algae and geothermal heat. These resources are renewable resources. Green energy, however, utilizes energy sources that are readily available all over the world. The most prevalent type of renewable energy is solar power which uses photovoltaic cell and converts sunlight into electricity. **Wind power is also a renewable energy;** Air flow on the earth's surface is used to push turbines, with stronger winds producing more energy. Hydropower depends on high precipitation levels to produce significant amounts of energy. Renewable energy provides reliable power supplies and fuel diversity, which enhance energy security, lower risk of fuel spills. Renewable energy also helps conserve natural resources. Green energy is sustainable, environment friendly, good availability, reduces electricity cost, improving technology, low maintenance. In other hand green energy can be expensive, exotic materials; it requires sufficient space as well. Coal is the carbon intensive, followed by oil and then natural gas. Green energy produces less pollution which protects the environment and provides cleaner air and water. Renewable energy is now most frequently the cheapest source of energy in the world. Compressed Natural Gas is safe, renewable, and environmental friendly. It is widely used in vehicles. Nuclear energy, it is one of the safest and cleanest sources of energy. Replacing fossil fuels with green energy sources helps reduce harmful emissions and cleans up air and water quality.

Key words: *Green energy, wind power, CNG*

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EVALUATION OF RELATIVE PERFORMANCE OF FRUIT TREE SPECIES UNDER HIGHLY SODIC SOILS

Shyamji Mishra* and Y.P. Singh

ICAR- Central Soil Salinity Research Institute, Regional Research Station, Lucknow
**Corresponding author email: shyamjimishra.019@gmail.com*

There seems to be a little scope for extending the area under crops because of developing activities with the ever increasing urbanization and thus, the fertile lands are limited for agricultural production/ orchards/ afforestation. Therefore, it is imperative to bring waste lands/ community lands/ salt affected lands which possess promise for growing of forest and fruit trees. Salt affected land occupied about 6.73 million ha in India. To rehabilitate these lands appropriate planting techniques and choices of fruit tree species are very crucial for reducing mortality and consequently for improvement in the initial establishment of saplings. In sodic soils a hard *Kankar* layer of calcium carbonate is generally found at a depth of about 80-120 cm. Therefore an experiment was conducted in sodic soils at ICAR-CSSRI, research farm, Shivri, Lucknow to study the comparative performance of 8 promising fruit species viz. pomegranate (*Punica granatum*), Guava (*Psydium guajava*),Karonda (*Carisa carandis*), mango (*Mangifera indica*), Imli (*Tamarandus indica*), Jamun (*Syzygium cuminii*), Amla (*Emblica officinalis*), and Ber (*Zizyphus mauritiana*). The saplings were planted in pits of 90 cm x 90 cm x 90 cm dimensions and in the auger holes of 45 cm diameter at the top and 20 cm at the bottom and 140 cm deep. These pits and auger holes were filled with original soil +15kg gypsum+20kg FYM+ 40kg silt and original soil+ 7.5kg gypsum+ 10kg FYM+20kg silt respectively. Nearly six months old saplings raised in a good soil were planted keeping row to row and plant to plant distance of 5m and 4m, respectively. Observation on survival, height and girth of fruit trees recorded after ten years of planting showed that among the eight species evaluated in the study, the survival of all the fruit species except *M. indica* was 100% under pit planting method. However, under auger hole plantation only 4 species such as *Z. mauritiana*, *C. carandis, P. guajava and S. cuminii recorded* 100% survival. The highest mortality under both the methods of planting was in *M. indica* and *P. granatum*. Among the species tested *S. cuminii, T. indica*, *E. officinalis and Z. mauritiana* gave best performance in terms of plant height and diameter under pit as well as auger hole methods of planting. *M. indica* and *P. granatum* did not perform well under both the planting methods. Probably prolonged water stagnation during rainy season affected *P. granatum* and *M. indica* adversely. On the basis of 10 years growth it was observed that, all the fruit species performed better under pit planting method. Among all the species tried, highest yield was recorded in *E. officinalis*. In pit method of planting *E. officinalis* yielded 2.67, 3.22 and 3.41 Mg ha^{-1} in 8^{th}, 9^{th} and 10^{th} year of planting respectively. However, the yield gap between two methods of planting was less in case of *C. carandis* and *P. guajava.* In general, soil pH near the plant (50 cm away from the stem) was almost same in pit and auger hole methods of planting in all the fruit species. However, the reductions in pH at 2 m away from plant at different depths were more under pit method as compared to auger hole method. Maximum reduction in surface pH (0-15 cm) at 2m away from the plant was recorded under *E. officinalis* plantation with pit planting method whereas, minimum with *T. indica* and *P. granatum.* The similar trend was also observed under auger hole planting method. In upper layers root biomass in pits was more than in auger hole because in auger holes, the roots were distributed in limited space, whereas in pits roots occupied more space and spread in all directions. The maximum organic carbon accumulation (3.5 g kg^{-1}) in surface soil at 2 m away from plant under pit planting method was also recorded under the canopy of *E. officinalis* while minimum under *P. granatum* because of its poor plant population and litter fall yield. The financial analysis based upon 8^{th}, 9^{th} and 10^{th} year observations indicated that pit planting method is more credit

worthy than auger hole planting but the planting cost per hectare using the pit method was almost double that of auger hole method. For pit planting method, the major expenditure was incurred during the pit digging operation. Based upon the benefit cost analysis, maximum benefit: cost ratio of 3.06, 2.91 and 2.48 after 8th, 9th and 10th year of plantation was worked out in *E. officinalis* under pit planting technique and the corresponding values under auger hole method of plantation were 1.53, 1.77 and 1.96 in respective years. On the basis of 10 years observations, it is concluded that *E. officinalis* followed by *C. carandis* and *P. guajava* have been identified most promising fruit species for planting in sodic soils.

Key words: *Fruit tree species, Performance, Sodic soils*

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RAINWATER HARVESTING AND GROUND WATER RECHARGING

Rajiv Shukla*

Department of Environmental Sciences, Kamla Nehru Institute of Physical and Social Science, Sultanpur-228132, Uttar Pradesh India

**Corresponding author email: srajivshukla121@gmail.com*

Every year in Monsoon our nature gives us our life in the form of rainfall but little beat of it is stored in the soil, damps, lakes etc. and remaining water get wasted in rivers. At the time of rainfall we didn't even recognize that running water but when the water level of our well's goes down then we think on it but at that time we can't do anything so we face water scarcity, only mean to say "When the well is dry, we learn the value of water". Now days we are reaching to the heights of development and covering all the earth surface by cement and concrete material but we are forgetting that we are closing the route of water to get entered in the earth's surface and it directly affects on our ground water level and we need face water scarcity. If this condition goes on then our new generation will face a high water problems for drinking and Agriculture purpose. Till about thirty years back, the areas around our homes and offices used to be unpaved and the rain falling on these areas would percolate into the soil and remain there for being drawn through shallow open wells. With the proliferation of flat complexes, not only have these areas been avid and percolation of rainwater into the soil almost totally stopped, the quantity of water drawn from the soil below has increased manifold. Consequently open wells and not-so-deep bore wells started drying up. The reason is that no sincere attempt is made to replenish the ground water table with rainwater during the monsoon. The Rainwater harvesting is the simple collection or storing of water through scientific techniques from the areas where the rain falls. It involves utilization of rain water for the domestic or the agricultural purpose. The method of rain water harvesting has been into practice since ancient times. It is as far the best possible way to conserve water and awaken the society towards the importance of water. The method is simple and cost effective too. It is especially beneficial in the areas, which faces the scarcity of water. People usually make complaints about the lack of water. During the monsoons lots of water goes waste into the gutters. And this is when Rain water Harvesting proves to be the most effective way to conserve water. We can collect the rain water into the tanks and prevent it from flowing into drains and being wasted. It is practiced on the large scale in the metropolitan cities. Rain water harvesting comprises of storage of water and water recharging through the technical process

Key words: *Percolate, Proliferation, Manifold*

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DAILY RIVER FLOW FORECASTING USING WAVELET ANN HYBRID MODELS

Manish Kumar[1*] and Pravendra Kumar[2]

[1]Ph.D. Scholar, Dept. of SWCE, G.B.P.UA.T, Pantnagar, Uttarakhand-263145,
[2]Professor, Dept. of SWCE, G.B.P.U.A.T, Pantnagar, Uttarakhand-263145
**Corresponding author email: manishcae2k11@gmail.com*

The advance time step streamflow forecasting is of paramount importance in controlling flood damage. During the past few decades, artificial neural network (ANN) techniques have been used extensively in streamflow forecasting and have proven to be a better technique than other forecasting methods such as multiple regression and general transfer function models. This study uses discrete wavelet transformation functions to preprocess the time series of the daily gauge and discharge flow data into wavelet coefficients of different frequency bands for Jamshedpur site of Jharkhand, India. Effective wavelet coefficients are selected from the correlation analysis of the decomposed wavelet coefficients of all frequency bands with the observed flow data. The input data for wavelet transformation was selected using the Gamma test. The preprocessing of data using wavelet transformation was done in Matlab software. The best model using wavelet transformation obtained was compared with a simple artificial neural network (ANN) techniques. The results found that the preprocessing of data with wavelet transformation was superior over the simple artificial neural network techniques.

Key words: *Gamma Test, Wavelet ANN, Coefficient of determination, RMSE*

23

RESPONSE OF VAM ON GROWTH AND YIELD OF POTATO

M. Raghav, Rajendra Bhatt and Priyanka

Department of Vegetable Science, College of Agriculture, G.B.P.U.A. & T., Pantnagar-263145, U.S. Nagar, Uttarakhand, India

A field experiment was conducted at Vegetable Research Centre of G.B.P.U.A. & T., Pantnagar (Uttarakhand) during *rabi* season of 2018-19 to examine the response of rallis rally gold granule on growth and yield of potato. Potato cultivar Kufri Surya, were subjected to nine treatments of different doses of rallis rally gold granule with recommended dose of fertilizer (RDF). Maximum emergence per cent, plant height, number of leaves and number of haulms were recorded with application of rallis ralli Gold G @ 4 kg/ac + RDF, rallis ralli Gold G @ 6 kg/ac + RDF, rallis ralli gold G @ 8 kg/ac + RDF and rallis ralli gold G @ 6 kg/ac + RDF, respectively. Among all the treatments rallis ralli gold G @ 8 kg/ac + RDF gave significantly more yield (37.3 t/ha) for Kufri Surya cultivar.

Key words: *VAM, Growth, Yield, Potato*

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DELINEATION OF ARTIFICIAL RECHARGE STRUCTURES IN HARD ROCK TERRAIN AREAS FOR SUSTAINABLE GROUNDWATER CONSERVATION USING REMOTE SENSING, GIS AND GEOPHYSICAL TECHNIQUE

V.J. Ganvir[1], Kaushlendra Singh[2], Aniket Khare[3], Pushpesh Kumar[4] and Mamta Yadav[5]

[1]Scientist- SE&Head GWRD, Remote Sensing Applications Centre, Lucknow UP
[2]Scientist-SD, SRD Division, Remote Sensing Applications Centre, Lucknow UP
[3]Student, Remote Sensing Applications Centre, Lucknow UP,[4]Project Scientist, Remote Sensing Applications Centre, Lucknow UP,[5]Project Scientist, Remote Sensing Applications Centre, Lucknow UP

The rapidly increasing need for water has put huge stress on groundwater resources in areas having groundwater as prime source of water. Due to improper extraction of groundwater without maintaining the balance with the recharging of the existing aquifer system, this problem will furthur aggravate. Artificial groundwater recharge is becoming increasingly necessary as growing population require more water and conversion of runoff water into ground water is needed for use in time of shortage or non-rainfall days. We have choosen Mandwara block of Lalitpur district for this study because it is a hard rock terrain area of Bundelkhand region and the surface water bodies get dried in summer season and people mostly depend on groundwater for irrigation and domestic purpose. Agriculture is the main source of income in this region and maximum irrigation is done through groundwater only. Survey of India toposheets and LISS III satellite imagery have been utilized to prepare various thematic layers viz. drainage, lineament, geomorphology and Land use/ Land cover map. SRTM 30m imagery has also been used to assess general runoff direction of the area and to prepare slope map of the study area. Using Geophysical technique surface electrical resistivity survey were conducted at 20 sites to collect sub surface lithological information, identification of horizontal and vertical disposition of aquifer system and also for recommendation of suitable artificial recharge structure for conservation of water during rainy season. The Overburden thickness and aquifer layer thickness maps have been prepared through GIS techniques using Geo-electrical data. All the thematic layers are exported to ArcGIS and different combinations were used to suggest various artificial recharge structures at a suitable site. Thus the above study has clearly shown the capabilities of Remote sensing, GIS and Geophysical technique to achieve the sustainable groundwater level in areas having similar geology and climatic conditions.

Key words: *Artificial groundwater recharge, Hard rock terrain, Satellite imagery, Remote sensing, GIS and Geophysical technique, ArcGIS, Sustainable groundwater level*

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COMPARATIVE STUDY OF DIFFERENT VARIETIES OF SUGARCANE AND SOIL HEALTH

Trilok Nath Rai, K. N. Rai, S.K. Rai and Vikas Singh

Krishi Vigyan Kendra (ICAR-IIVR), Sargatia, Seorahi, Kushinagar-274406 (U.P.)

Krishi Vigyan Kendra (ICAR-IIVR), Sargatia, Seorahi, Kushinagar assessed the comparative performance of different sugarcane varieties at KVK farm in district Kushinagar UP in the year 2013 to 2015 . Under investigation varieties like CoSe 5451, CoSe 96436, UP 5125, Co 86032 and CoSe 1434 have been taken. Result shows that planting of sugarcane variety Co 86032 in paired row in trenches

gave higher yield i.e. 625.35 q/ha in comparison to rest of the varieties. The yield of other varieties stood at 605.55, 515.45, 525.35 and 505.25 q/ha respectively for UP 5125, CoSe 5451, CoSe 1434 and CoSe 96436. Sowing of sugarcane in paired row saved seed, fertilizer, fuels, water and man power and increased the productivity of crop. The weight of per sugarcane average was recorded maximum in the variety Co 86032 i.e. 1.30 to 1.38 kg. The average plant height, softness, nutrient use efficiency, water use efficiency and weight of sugarcane was recorded maximum in the variety Co 86032. After harvesting of crop, improvement in soil health were recorded in paddy straw mulch plots.

Key words: *Sugarcane, Yield, Varieties*

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CROPPING INTENSITY IN KUSHINAGAR AND SOIL HEALTH

Trilok Nath Rai*, K.N. Rai, S.K. Rai, Vikas Singh and J. Singh

**Subject Matter Specialist (T-8), Soil Science/Agronomy, Krishi Vigyan Kendra (ICAR-IIVR), Sargatia, Seorahi, Kushinagar-274406 (UP)*

KVK, Kushinagar assessed the technology of intensification and diversification of irrigated rice-wheat cropping system at 5 farmers' field. Cropping intensity of district Kushinagar is 155.25 % due to sugarcane as sole crop. In case of rice –wheat system it is only 200%. During Kharif season Rice var P 2511 gave 40.25 q/ha in 125 days in comparison to farmers' practice (BPT5204) that gave 22.75 q/ha in 147 days mainly due to dry spell and scattered rainfall. Short duration variety saved 20 days of cropping period so that in rabi season farmers took advantage and timely sown –Toria (var. PT 303 and Uttara) and got 7.45 q/ha from PT 303 and 6.25 q/ha from Uttara, respectively in comparison to farmers practice of growing wheat var. HUW-234 which gave yield of 20.15 q/ha due to delayed sowing and delayed harvesting of paddy and preparation of land. During Zaid season farmers sowed Cowpea variety Kashi Kanchan after harvesting of Toria as vegetable crop. In the trial T_1 cropping intensity increased 300 % (Paddy P-2511- Toria PT 303/ Uttara- Cowpea Kashi Kanchan) in comparison to farmers practice giving only 200 % (Paddy BPT 5204 - Wheat HUW 234 followed by fallow land). After harvesting of cowpea improvement in soil health were recorded in the plots.

Key words: *Cropping intensity, Soil health*

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CHARACTERISTICS OF DIFFERENT SUGARCANE VARIETIES AT KRISHI VIGYAN KENDRA (ICAR-IIVR), SARGATIA, SEORAHI, KUSHINAGAR UP & SOIL HEALTH

Trilok Nath Rai, S. K. Rai and K. N. Rai

Krishi Vigyan Kendra (ICAR-IIVR), Sargatia, Seorahi, Kushinagar-274406 (UP)

Krishi Vigyan Kendra (ICAR-IIVR), Sargatia, Seorahi, Kushinagar assessed the comparative performance of different sugarcane varieties in district Kushinagar UP during the year 2015 to 2019. Varieties Co 0238, Co S 08272 and Co Se 8452 have been taken. Results show that planting of sugarcane in paired row in trenches with variety Co 0238 gave higher yield i.e. 725.35 q/ha over the rest of the varieties. The yield of other varieties recorded were 610.55 and 610.45 q/ha for Co S 08272 and CoSe 8452, respectively. Sowing of sugarcane in paired row saved seed, fertilizer, fuels, water and man power and increased the productivity of crop. The average weight of sugarcane was recorded maximum in the variety Co 0238 i.e. 2.30 to 3.35 kg. The average plant height, softness, nutrient use efficiency and water

use efficiency was maximum in the variety Co 238. After harvesting of crop, improvement in soil health were recorded in paddy straw mulch plots.

Key words: *Sugarcane, Yield, Varieties*

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PHYSICO-CHEMICAL ANALYSIS OF GROUND WATER USING GIS AND GPS: A CASE STUDY OF SAHJANWA AND PIPRAULI BLOCK OF GORAKHPUR DISTRICT, UP

Apoorva[1*], Arvind Mathur[2], Sandeep Kumar[3] and Anup Agrahari[4]

M.Sc. Student, University of Lucknow
**Corresponding author email: apoorvatripathi1296@gmail.com*

Water is the elementary component of social and economic infrastructure and is critical for healthy society and sustainable development. Due to the immense increase in the density of population, fast urbanization, industrialization and agricultural practices, the demand of water is increasing day by day. As a result, surface water and ground water level is decreasing, pollution and increased demand have made good quality water scarce and more expensive. The possibility of ground water toxicants is due to the mixing up of toxic chemicals, fertilizers, waste disposed sites and industrial wastes. Hence, monitoring of ground water quality has become integral. In this project, ground water quality analysis was carried out for Sahjanwa and Piprauli block of Gorakhpur District. The strategically analyzed results are represented in the form of map using ArcGIS 10.2.2. Drinking water samples from INDIA MARK II were collected from both the blocks of the District and were analysed for physico-chemical characteristics. The samples were collected and studied in 2019 in 21 locations across villages of both the blocks. The present study intended to calculate the certain specific water quality parameters for drinking water that is pH, Electrical Conductivity (EC), Total hardness (TH), Total dissolved solids (TDS), Nitrates (NO_3). Each parameter was compared with the standard permissible limit prescribed by BIS (IS 10500:2012). This study is carried out with the purpose of calculation of water quality status of both the blocks and demarcation of contaminated areas so that the proper corrective procedures can be taken.

Key words: *Water Quality, GIS, Global positioning system*

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BENCHMARK SURVEY OF KONIYA VILLAGE FOR NATURAL RESOURCE MANAGEMENT IN BUNDELKHAND REGION OF UP

M.P. Singh[1], M.K. Singh[2] and Mukesh Chand[3]

[1]SMS (Agril. Extension) Krishi Vigyan Kendra, Kaushambi, [2]SMS (Soil Science), Krishi Vigyan Kendra, Kaushambi, [3]Sr. Scientist & Head, Krishi Vigyan Kendra, Mahoba

Benchmark survey of Koniya village in Panwari Block of Mahoba district was undertaken during 2018-19 with the purpose of adopting it as a KVK village for doubling farmer's income with emphasis on Natural Resource Management. To fulfill the objectives of the study, primary data was collected by using PRA (Participatory Rural Appraisal) tools and personal interview of the households along with a general survey of the entire village. The findings of the survey revealed that the farming system prevailing in the area was pulse based cropping system with livestock and homestead as secondary activities. The major growing pulses during *kharif* season are black gram (Urad), green gram (mung) and pigeon pea (arhar) and during *rabi* season, field pea (matar), chickpea (chana) and masoor are predominant. The

study concluded that the farming system of the village is mostly influenced by the soil types, rainfall and irrigation facilities. These are mono-cropping system and about 55% area is being left fallow during Kharif season. During winter season, about 58% area is sown as rainfed due to rocky terrain and lack of irrigation facilities. Important vegetables like tomato and brinjal are grown as cash crops near pump sets of wells and periphery of ponds. Livestock is the backbone of farming systems hence unimproved breeds and poor nutritional management causes low productivity.

Key words: *Benchmark survey, PRA, Natural Resource Management*

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ASSESSMENT OF SALT TOLERANT MUSTARD VARIETY (CS 58) WITH CSR BIO IN KAUSHAMBI DISTRICT

M.K. Singh[1] and M.P. Singh[2]

[1]SMS (Soil Science), Krishi Vigyan Kendra, Kaushambi, [2]SMS (Agril. Extension), Krishi Vigyan Kendra, Mahoba

Mustard (*Brassica juncea L.*) is an important oilseed crop of Kaushambi district. District has about 18,500 ha area under salt affected soils mainly sodicity. Because of high salt content in soil the productivity of traditional mustard varieties is very low. Development of salt tolerant cultivars is seen as a viable means of mustard productivity enhancement under saline conditions. ICAR-CSSRI, Karnal has developed promising salt tolerant variety of Indian mustard 'CS 58' for salt affected mustard growing regions of Haryana, Punjab and Uttar Pradesh. To evaluate the comparative performance of newly developed salt tolerant Mustard variety CS-58 and local variety varuna, on-farm trials were conducted by Krishi Vigyan Kendra, Kaushambi on four farmers' field during *rabi* 2018 and 2019. Before sowing, the seed of both the varieties was treated with bio growth enhancer CSR BIO @ 30ml/kg seed. The pH of the study plots ranged from 8.8 to 9.2. Two years yield data revealed that salt tolerant variety CS 58 treated with CSR BIO produced significantly higher yield (18.59 q/ha) than local check Varuna (16.9 q/ha). The cost economics calculated for mustard cultivation in both varieties revealed that the net return and B:C ratio of CS 58 was better than the Varuna in both the years. With the introduction of CS 58 in the villages, the area under salt tolerant variety has increased in the village and they are producing seed of salt tolerant variety for larger scale dissemination.

Key words: *Mustard, Sodic soil, Salt tolerant variety*

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OPTIMIZING FERTILIZER DOSE FOR TOMATO CROP ON THE BASIS OF SOIL TEST VALUE IN KAUSHAMBI DISTRICT OF UTTAR PRADESH

M.K. Singh[1], M.P. Singh[3] and J.P. Singh[2]

[1]SMS (Soil Science), Krishi Vigyan Kendra, Kaushambi, [2]SMS (Agril. Extension), Krishi Vigyan Kendra, Mahoba, [3]SMS (Horticulture) Krishi Vigyan Kendra, Kaushambi (UP)

A field trial was carried out by Krishi Vigyan Kendra, Kaushambi on 4 farmers' fields in four villages covering 0.4 ha area in Kaushambi district during *rabi* 2018 to optimize the fertilizer dose for tomato (*Lycopersicum esculentum Mill.)* crop on the basis of soil test value. The average available N, P, K and S in the trial fields were 103.5, 9.0, 246 and 11kg/ha, respectively. The fertilizer treatments consisted of farmers practices and recommended dose of fertilizer (NPK-120:60:80 + 25 kg/ha sulphur) were applied to the crop following recommended method of fertilizer application. Result indicated that the tomato yield in plots fertilized with farmers practices and recommended dose on soil test value were 310.28 q/

ha and 490.22 q/ha, respectively. The tomato yield in plots fertilized on the basis of soil test value was 58% higher over farmers' practices. The benefit cost ratio in recommended dose of fertilizer and soil test value were 6.7 and 4.2, respectively.

Key words: *Tomato, Recommended dose, Nutrient Management*

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DETERIORATING WATER QUALITY OF GOMATI RIVER AND ITS REJUVENATION AT LUCKNOW CITY STRETCH

Ankit Kumar[1, 2], Alok Kumar[1], Pankaj Maurya[1] and Ganesh Chandra Kisku*[1,2]

[1]Environmental Monitoring Laboratory, Environmental Toxicology Group, CSIR-Indian Institute of Toxicology Research, Vishvigyan Bhawan, Lucknow-226001, UP, India,[2]Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India
**Corresponding author email: gckisku@iitr.res.in, kiskugc1@rediffmail.com*

Gomati river originates from a natural lake near Madho-Tanda village in Piliphit, UP about 50 km south of the Himalayan foothills. River flowing through 9 districts ~940 km and finally merge with the Ganges at Ghazipur in Varanasi. Gomati travels 16 km in south-east direction at Lucknow. Construction activities, municipal sewage and industrial waste water are the major cause of water contamination. Gomati receives polluted water through 26 drains in Lucknow area. The average value of key indicator parameters of water quality like DO, BOD and COD were 5.2, 10.3 and 31.1 mg/L, respectively. The average value (µg/L) of Cd 4.2, Co 3.1, Cu 0.2, Fe 316.2, Pb 3.5, Mg 18.2, Mn 45.4, Ni 0.6, Zn 12.4 and Hg 3.1 ng/L were found. The concentration of organo-chlorine pesticides ranged between 0.05 to 0.14 µg/L, average 0.07 µg/L. The most probable number bacterial count index/100 ml ranged from 430 to >1600 which indicates Gomati water is not fit for human consumption and for aesthetic values. High input of these chemicals deteriorates Gomati water quality and found to be unsuitable for aquatic organisms viz. snails, zooplankton, phytoplankton, turtles, amphibians and fishes. Results found that some water quality parameters were beyond their permissible limit. Gomati water quality is moderately polluted. Our main aim is to increase public awareness to Gomati river water pollution in Lucknow city area so that administrative measures could be taken in advance to protect the water quality and aquatic ecosystem. We also recommend how Gomati river can rejuvenate from polluted to healthy river system.

Key words: *Water Quality, Gomati River, Pesticides, Physiochemical Parameters, Heavy Metals*

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ROLE OF SOIL NUTRIENTS AND GERMPLASM CONSERVATION: NEED FOR SOIL NUTRIENT INDEXING FOR BETTER RESOURCE USE EFFICIENCY

Tarun Adak*, Kailash Kumar and G. Pandey

Division of Crop Production, ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow-226101, UP, India.
**Corresponding author email: tarunadak@gmail.com*

Soil nutrient always play key role in any agri-horticultural system to show the status of ecosystem productivity. Nutrient deficiency lowers the scope of enhancing resource use efficiency. Thus, need for nutrient indexing is there in order to sustain economic growth of orchards. In this connection, IIHR collaborative project on "Micronutrient management in Horticultural crops for enhancing Yield and

quality" was conducted and soil, foliar and pulp nutrients in mango germplasms were quantified. The fruit cracking percentage in cultivars of mango varied between 12.4 to 36.7% (Dashehari to Lemon). Boron concentration in cracked fruits and the associated leaves was invariably lower than that in the normal fruits and associated leaves indicating that lower B content in the leaves and fruits is an indicative factor for nutrient deficiency. The fresh weight in pulp, peel and stone of Langra, Chausa, Amarapali, Lucknow Safeda and Mallika cultivars varied from 66.62 to 75.52, 13.15 to 16.55 and 9.60 to 17.45 percentages while the corresponding values on oven dry basis were 16.02 to 18.05, 25.0 to 32.22 and 33.6 to 55.03 percentages, respectively. Lower potassium and boron content in fruit pulp was also recorded suggesting the need for proper nutrient management to improve the orchard use efficiency. In order to indicate the mango orchard ecological status, soil nutrient index (SNI) was developed and results showed low to medium SNI. Research achievements strongly recommended for precision management of valuable nutrients for greater resource use efficiency.

Key words: *Soil nutrients, Germplasm conservation, Soil nutrient indexing, Resource use efficiency*

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TOWARDS BETTER WATER USE EFFICIENCY IN MANGO THROUGH DRIP FERTIGATION

Tarun Adak*, G. Pandey and Kailash Kumar

Division of Crop Production, ICAR- Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow-226101, UP, India.
**Corresponding author email: tarunadak@gmail.com*

Advanced soil and water management is the utmost requirement for improving the input use efficiency across different soil-crop-climatic situation. Orchards need site specific management and fruit crops bears the heat and water stress during the fruit set to development stages yielded low and thus reduces the system productivity. Maintenance of optimum soil moisture regime during the critical stages was thus called for. Farmers' practice of flooding in mango orchards resulted in greater reduction of ground water coupled with water loss. Indigenous use of pitcher, wells, pond etc also provides safe way of maintaining moisture regime. However, role of drip fertigation enhanced the scope further by reducing water loss and improving the efficiency. Rainwater harvesting by creating farm pond offers great scope particularly in rainfed areas for future water use. A range of 10.8 to 27.7 percentage enhancement in water use efficiency was recorded in drip fertigation system than basin irrigated orchards. Further, yield improvement to the tune of 15.2 to 59.9per cent in fertigated system applied was recorded as compared to control trees of having only basin application. When compared within the fertigation system, the best response was observed application in critical stage wise and yield improvement in 75 per cent recommended fertilizer fertigation system was 16.5 and 38.8 percentages higher as compared to 50 and 25per cent recommended fertigation system. Enhancing the water use and its efficiency was thus crucial across different soil-crop-water management in different agroclimatic regions.

Key words: *Mango, Water use efficiency, Drip-fertigation*

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IN VITRO DEGRADATION OF IMIDACLOPRID IN STERILE AND NON-STERILE SOIL BY MICROBIAL CONSORTIUM

A.K. Bhattacherjee, Pradeep K. Shukla, Abhay Dikshit and Neelima Garg

Division of Post Harvest Management, ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Kakori, Lucknow, India

In vitro degradation of imidacloprid in sterile and non-sterile soil by microbial consortium (five bacteria and four fungi strains, isolated from imidacloprid treated mango orchard soil) were studied under laboratory conditions. In petriplates, ten gram soil sampleswere treated with two concentrations of imidacloprid (99%, 5 and 10 ppm), maintainedin triplicate and kept at room temperature up to 50 days along with control (without microbes but with pesticide). Sampling was done at 10 days interval (0, 10, 20, 30, 40 and 50 days after treatment) to analyze the degradation. In non-sterile soil, better degradation by microbial consortium was obtained from lower dose (5 ppm – 52.63%) than higher dose (10 ppm – 25.76%), whereas in control soil, 10 ppm imidacloprid degraded faster (41.57%) than 5 ppm imidacloprid (30.77%) after 50 days. In case of sterile soil significant degradation of insecticide by microbial consortium was recorded after 50 days in both the concentrations (72.7% in 5 ppmand 73.21% in 10 ppm after 50 days). Though the variation in level of degradation among two concentrations was minimal, but it was significantly higher (around 20%) than that in control soil (51.86 and 54.01% for 5 and 10 ppm concentrations, respectively). The degradation of imidacloprid followed first-order rate kinetics in all the soil samples (sterile or non-sterile, with or without microbes). The present studyconcluded that microbial consortiumcould beused effectivelyfor degrading imidacloprid in sterile soil under laboratory conditions.

Key words: *Imidacloprid, degradation, sterile soil, non-sterile soil, microbial consortia*

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ASSESSMENT OF EARLY SUGARCANE GENOTYPES OF ADVANCED VARIETAL TRIAL FOR CANE PRODUCTIVITY IN NORTH EASTERN ZONE

Satendra Kumar[1*], M.L. Srivastav[1], S.P. Yadav[2], S.C. Singh[2] and Pratap Singh[1]

[1]*Genda Singh Sugarcane Breeding and Research Institute, Seorahi, Kushinagar*
[2]*UP Council of Sugarcane Research, Shahjahanpur (UP)*
[*]*Corresponding Author email: satendrayadav.agro@gmail.com*

Sugarcane varieties may play very important role in achieving the doubled farmers' income which is aim of our government and also it is one of the most important crop in the country occupying about 5.0 million hectare area. The most important factor is ability of genotypes to efficiently utilize the major applied nutrients especially NPK. An experiment was conducted during 2018-19 at research farm of Genda Singh Sugarcane Breeding and Research Institute, Seorahi, under AICRP on sugarcane with twentyfour treatment combinations. Three genotypes i.e. Co P 13437, Co Se 13451, Co Se 13452 and three standards i.e. Co Lk 94184, Co Se 95422 and Co Se 01421, two fertility levels i.e. 100 and 125 per cent recommended dose of NPK and two spacing i.e. 90 cm and 120 cm row spacing were tested in factorial randomized block design and replicated thrice. Recommended dose of N, P and K was 180, 80

and 60 kg/ha and was applied as per treatment. The experimental field was medium in organic carbon, available phosphorus (22.13 kg/ha) and low in potash (58.40 kg/ha) with pH 8.07. Crop was planted on 08 March, 2018 and harvested on 29 March, 2019. Co Se 13452 gave significantly higher germination (43.24%), shoot population (154670/ha) and NMC (89640/ha) over check Co Se 01421 but significantly higher cane yield over all the zonal checks. Co Se 13451 recorded significantly higher cane yield as compared to zonal checks i.e. Co Lk 94184 and Co Se 01421. Genotype Co P 13437 recorded lower germination per cent, shoot population against all zonal checks but NMC (85420/ha) was significantly better than check Co Se 01421. Performance of Co P 13437 in relation to cane yield was significantly better against zonal checks Co Lk 94184 and Co Se 01421. Effect of row spacing on shoot population, NMC and cane yield was recorded significantly better with 90 cm row spacing and produced significantly higher shoot population (161970 per ha), NMC (102580 per ha) and cane yield (80.99 t/ha) over 120 cm row spacing but sucrose per cent were obtained significantly higher in 120 cm row spacing. Effect of fertility on germination and sucrose per cent were noted non significant but 125 per cent recommended dose of NPK produced significantly higher shoot population (149000 per ha), NMC (93030 per ha) and cane yield (76.89 t/ha) as compared to 100 per cent recommended dose of NPK.

Key words: *Assessment, Sugarcane, Fertility, Genotypes, Double income*

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GIS BASED MORPHOMETRIC ANALYSIS OF FOREST WATERSHED USING HIGH RESOLUTION SATELLITE DATA

Vishnu Prasad*, Abrar Yousuf and Navneet Sharma

Department of Soil and Water Engineering, Punjab Agricultural University, Ludhiana, 141004
**Corresponding author email: dewanganvishnu1000@gmail.com*

Management of natural resources particularly soil and water are very important. The watershed is considered to be the ideal unit for management of natural resources. Remote sensing and GIS, being efficient, accurate and time saving techniques, have found great application for management of natural resources. In the present study, remote sensing and GIS have been used to evaluate the morphometric parameters of the *Dada* watershed located in the lower Shivaliks of Punjab. The high resolution ALOS PALSAR (DEM) having spatial resolution of 12.5 m has been used for calculating various morphometric parameters such as linear aspect, aerial aspect and relief aspect of the watershed morphometry. Morphometric parameters such as stream order, stream length, stream frequency, drainage density, form factor, circulatory ratio, elongation ratio, bifurcation ratio, compactness coefficient etc. have been evaluated. The total area and perimeter of the study watershed is 1491.1 ha and 29.1 km. The results of the study revealed that the *Dada* watershed is 5^{th} order drainage basin. It was observed that total number of streams in the study watershed are 377 out of which 216 are of 1^{st} order, 94 are of 2^{nd} order, 60 are of 3^{rd} order and 6 are of 4^{th} order. The total length of streams is 71.98 km and mean stream length is 190.92 m. Drainage density of the watershed is 4.83 km/km^2 while as drainage texture and length of overland flow are, respectively, 30.45 no./km and 71.23 m. The watershed is having stream frequency of 25.283 no./km^2 and mean bifurcation ratio of 4.97. The watershed has form factor of 0.27, circularity ratio of 0.22 and the elongation ratio of 0.586 in the watershed. This study would be helpful for local people and related departments to utilize the resources for planning rainwater harvesting and watershed management. The present study shall be useful to understand the hydrologic behaviour of the watershed and planning and management of water resources of the study watershed.

Key words: *Morphometry, Watershed, Lower Shivaliks, DEM, GIS*

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EFFECT OF INCLUSION OF A LEGUME, TILLAGE, RICE RESIDUE MANAGEMENT ON THE WATER PRODUCTIVITY AND PERFORMANCE OF THE RICE-WHEAT CROPPING SYSTEM

Amit Mishra[1], U.P. Shahi[2], Vipin Kumar[3], Vivek Kumar[4], S.K. Sharma[5] and Sheetal Sharma[6]

[1]Assistant Professor, Banda University of Agriculture & Technology, Banda
[2]Associate Professor, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut,[3,4,6] International Rice Research Institute,[5] Ex. Director Indian Institute of Farming System

Rice- wheat cropping system is the predominant contributor of the food grain production of India, where rice is established by transplanting of seedling in puddled soil, and wheat crop seeding is shifting from conventional broadcasting to line sowing by zero seed cum fertilizer drill. The main challenge of present scenario is to maintain trend of increase in food grain production without deteriorating natural resources i.e. soil and water. Hence adoption of resource conservation technologies is utmost important for attaining the agricultural sustainability. Therefore, an experiment was initiated at SVPUA&T, Modipuram during *Rabi* 2012-13 and 2013-14 and *Kharif* 2013. The objective was to evaluate the effect of legume, tillage and crop residue management on the water productivity and performance of rice – wheat crop rotation. The experiment was laid out in spilt plot design with 3 replications, in main plot treatments on tillage and inclusion of green gram viz. T1: conventional tillage direct seeded rice (*Kharif*) and zero tillage wheat (*Rabi*) (CTDSR fb ZTW) ; T2: conventional tillage direct seeded rice and zero tillage wheat and green gram (Zaid) (CTDSR fb ZTW fb GG); T3: zero tillage direct seeded rice and zero tillage wheat (ZTDSR fb ZTW) ; T4: zero tillage direct seeded rice and zero tillage wheat and zero tillage green gram (ZTDSR fb ZTW fb GG) and residue retention in sub plot (S1: with full residue retention and S2: without residue retention (cut at 5 cm) were taken. Around 8 t ha^{-1} residue was retained in plots (as per treatment).

During *Rabi* season 2012-13 & 2013-14, the similar trend was observed during both years, the findings revealed that maximum effective tillers and grain yield were recorded with T4 (ZTDSR fb ZTW fb GG) in full residue retention plot as compared to the other treatments. In year 2012-13, similarly higher water productivity was recorded withT4 with residue (11.21 kg grain mm^{-1} water) which was similar to T1 with residue (10.86 kg grain mm^{-1} water) and T2 with residue (10.72 kg grain mm^{-1} water) but significantly higher than remaining treatments with or without residue.

During *Khairf* 2013, interaction between treatment and crop residue was found to be significant for rice panicle density T4 with crop residue recorded the maximum plant density of 280 m^{-2} which was higher than the T1 with or without residue and T3 without residue but similar to T2 with or without residue, T3 with residue and T4 without residue. Similarly, grain yield, T2 without crop residue gave the higher yield of 7.5 t ha^{-1} which was similar to T2 with residue (7.03 t) but statistically superior than remaining other treatments. Further, under ZT condition and green gram did not influence the yield.

Zero tillage along with rice residue retention showed positive effect on wheat crop grain yield and water productivity, however, contrast finding was found with direct seeded rice in which performance of DSR was better under conventional tillage than zero tillage.

Key words: *Direct Seeded Rice, Zero till Wheat, Residue Retention, Water Productivity*

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INTEGRATED FARMING SYSTEM FOR DOUBLING FARMERS' INCOME

Iska Srinath Reddy* and Arun Alfred David

[1]Department of Soil Science and Agricultural Chemistry,Sam Higginbottom University of Agriculture Technology and Sciences,Prayagraj- 211 007, UP, India

*Corresponding author email:iskasrinathreddy@gmail.com

Indian context, the prosperity of a country depends upon the welfare of farmers and majority of the Indian farming communities follow traditional norms of agriculture which support their livelihood. Farming in India is characterized by small, marginal, and fragmented land holdings (about 86%) and is highly depended on monsoon showers. Environmental degradation including ground water contamination and entry of toxic substance into the food chain has become a significant problem. Nearly 72.2% population of India is living in 6.38 lakh villages, mostly dependent upon agriculture and livestock for their livelihood. Crops productivity is largely restricted by uncertain and erratic rainfall, scarcity of water for irrigation and deterioration of soil-health. 90% farmers are marginal hold 0.5 to 1.0 ha of land In IFS systems all agricultural enterprises including animal husbandry, fishery, bee keeping, goat rearing, cropping systems, fruits, vegetable and others are setup into a single unit of land and Vertical expansion in small farms is possible by integrating appropriate farming system components requiring less space and time and ensuring periodic income to the farmers. Vital strategies need to be adopted considering the basic requirements of the farmers. These strategies might be massive investments in agricultural research and development, adoption of Good Agricultural Practices (GAP), conservation agriculture technology, implementation of farmers friendly policies, judicious use of available resources and inputs, along with improved market and transportation facility, minimum support price (MSP) reform, supported by adequate and timely availability of bank credits. Smart farming and credit supporting smart farming are other possible strategies in doubling farmer's income. Economic and socioecological access to sustainable production could be only ensured by adopting farming system approach.

Key words: *IFS, cropping system, farmer, livelihood, income*

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EVALUATION OF HERBICIDES ON GROWTH AND YIELD OF DRY DIRECT SEEDED RICE *(Oryza sativa* L.*)*

Manvendra Singh[1] and Manoj Kumar Singh[2]

[1]Research Technician, International Rice Research Institute-South Asia Regional Centre, Varanasi (UP).[2]Soil Scientist, Krishi Vigyan Kendra, Kaushambi (UP)

Transplanted rice is the widespread practice of rice cultivation in world and also in Indo Gangetic Plains (IGP) of India. Transplanted rice and succeeding crops mainly wheat have diverse edaphic requirements, annual conversion of soil from aerobic to anaerobic conditions for transplanted rice and then back to aerobic conditions for succeeding crop is a big threat for sustainability of food production system. Rice production systems are undergoing numerous changes in establishment methods of rice cultivation and one of such alternative is direct dry or wet seeding of rice. Direct seeding of rice by either dry or wet establishment methods is spreading rapidly as the farmers search for high productivity and profitability to offset mounting cost and paucity of farm labour. Dry direct seeding of rice establishment method offer water saving of 11-18% in irrigations and reduces total labour requirement but lacks a weed infestation due to dry tillage, absence of standing water and alternate wetting and drying during early part of crop growth. As the weeds and rice emerge simultaneously in Dry DSR, the proper time and method of weed control remains a complex phenomenon. In view of the above advantages and

disadvantages a field experiment was laid out in randomized block design consisting twelve treatments and three replications. The treatments included Ethoxysulfuron @ 100 g/ha (Pre-emergence), Ethoxysulfuron @50 g/ha (Pre-emergence), Flufenacet @200 g/ha (Pre-emergence), Flufenacet @100 g/ ha (Pre-emergence), Cyhalofop-butyl 210 g/ha (Post-emergence), Cyhalofop-butyl @105 g/ha (Post-emergence), Ethoxysulfuron @100 g/ha + Cyhalofop-butyl @105 g/ha (Pre-emergence + Post-Emergence), Ethoxysulfuron @ 50 g/ha + Cyhalofop-butyl @ 210 g/ha (Pre-emergence + Post-Emergence), Flufenacet @ 200 g/ha + Cyhalofop-butyl @105 g/ha (Pre-emergence + Post-emergence), Flufenacet @100 g/ha + Cyhalofop-butyl @ 210 g/ha (Pre-emergence + Post- emergence), hand weeding (20 and 40 days) and un-weeded check. The soil of the experimental field was sandy loam in texture having 7.70 pH. Experimental field was dominated by weeds like *Commelina benghalensis* L., *Parthenium hysterophorus* L, *Cynodon dactylon* (L.) Pers and *Cyperus rotundus L.* were observed at 20 DAS and they declined up to 60 DAS. There was no emergence of *Parthenium hysterophorus* L. and *Commelina benghalensis* L. in the plots treated with pre-emergence application of Ethoxysulfuron @ 50 and 100 g/ha followed by post-emergence application of Cyhalofop- butyl @ 105 and 210 g/ha. The emergence and development of weeds was controlled with the application of Ethoxysulfuron @ 100 g/ha followed by post-emergence application of Cyhalofop- butyl @ 105 g/ha. It resulted in least density and dry weight of weeds as well as highest growth, grain yield and yield attributes of dry direct seeded rice. Economically, pre-emergence application of Ethoxysulfuron @ 100 g/ha followed by post-emergence application of Cyhalofop-butyl @ 105 g/ha resulted in maximum net return and benefit cost ratio.

Key words: *Dry-direct seeded rice, Herbicide, Rice, Growth and yield*

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NUTRIENT MANAGEMENT AND PLANT GEOMETRY FOR PROMISING SUGARCANE GENOTYPES

Shri Prakash Yadav[1]*, S.C. Singh,[2] Shravan Yadav[3] and Arvind Kumar[4]

[1]Scientific officer (Agronomy), [2]Senior Scientific officer (Agronomy), [3]Agriculture Supervisor (Agronomy),[4]Scientific officer (Plant Breeding), Sugarcane Research Institute, Shahjahanpur242001 (UP)

**Corresponding author email: drshriprakshyadav@gmail.com*

The major causes for lower productivity of ruling verities of sugarcane are conventional planting methods, drought and imbalance nutrient management practices which result in lower number of millable canes and lodging and ultimately lower cane yield. Considering these points in views a field experiment was conducted with early maturing promising sugarcane genotypes namely CoS 13231, CoS 13235, CoS 14231 and CoS 10231 along with two fertility levels i.e., 100% recommended dose of NPK and 100% recommended dose of NPK+25% N through organic manure+ biofertilizers (PSB+Azotobacter) 10 kg/ha each with two methods of paired row planting i.e. in trenches, 30:90cm and 30:120 cm. Experiment was laid out in factorial randomized block design with three replications. Soil was sandy loam in texture with 7.2 pH, low in organic carbon (0.38%) and available phosphorus (7.61 kg/ha) and medium in potassium (169 kg/ha). Mean data of two years indicated that the genotype CoS 13235 of early group produced significantly higher cane yield (87.20 t/ha) as compared to other varieties. The cane yield increased significantly with fertility level of 100% recommended NPK+25% N through organic manure+biofertilizers (PSB+ Azotobacter)@ 10kg/ha each. The 30:90 cm plant geometry was found better than 30:120 cm paired row planting in trench for all the promising verities. Juice quality was better in CoS 13235 and CoS 13231 as compared to other two genotypes, while juice quality was not influenced by increasing fertility levels and various planting geometry.

Key words: *Precision nutrient management, Sugarcane, Plant Geometry, Fertility levels*

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TRANSFORMING TRANSIENT DRAIN SPACING FORMULA TO PREDICT WATER TABLE FLUCTUATION IN RESPONSE TO CONSTANT RECHARGE

Chhedi Lal Verma[1] and Rohit Pratap Ojha[2]

[1]Senior Scientist, [2]Senior Research fellow

ICAR- Central Soil Salinity Research Institute, Regional Research Station, Lucknow 226002

Lowering of water table is one of the basic necessities for the reclamation of waterlogged saline and alkaline soils. Subsurface drainage is a well-recognized engineering measure for lowering water table of waterlogged salt affected soils. The design of drainage system for controlling salinity and excess moisture is based on the control of water table position for a given hydraulic and hydrologic situation. Information on water table fluctuation is the most important for correlating crop yield and drainage performance and also optimizing the drain spacing. Transient formulas (Glover (1954) Dumm 1(960), Inegrated Hooghoudt and Integrated Toksoz-Kirkham (1963), van Schilfgaarde (1963), Modified Glover (1964), Integrated Dagan (2002)) are available for drain spacing calculation for falling water table conditions. A large number of mathematical models are also available for predicting water table fluctuation in response to recharge (Wiser et al. (1974), Kraijenhoff van de Leur (1958), Maasland (1959), de Zeeuw and Hellinga (1958), Dumm (1960), van Schilfgaarde (1965) and Skaggs (1982)). Kraijenhoff van de Leur (1958) and Maasland (1959) derived identical theoretical equations independently for simulation of water table fluctuation between two subsurface drains in response to various recharge patterns. Uzaic and Chieng (1988) derived drain spacing formula having elliptical shape of water table. Dumm (1960) drain spacing formula had been also used for predicting water table fluctuations assuming instantaneous rise in water table due to constant recharge. These models can be used to predict water table heights for any length of time. de Zeeuw and Hellinga (1958) and van Schilfgaarde (1965) transformed the Hooghoudt's drain spacing formula and Kirkham's drain spacing formula using an empirical relationship to predict transient water table behavior in response to constant recharge on daily basis, respectively. These equations ignore flow above drain level while calculating water table depth in response to constant recharge. In the present study a new methodology is proposed to transform any transient drain spacing formula for predicting water table fluctuations in response to rain or irrigations. Integrated Hooghoudt (van Schilfgaarde, 1963) transient drain spacing formula which takes flow above drain level also into account has been transformed to predict water table fluctuation in response to constant intermittent recharge by proposed method. The equation was tested in subsurface drained fields with drain spacing of 50 m and 75 m and compared with Glover (1954), Dumm (1960), de Zeeuw-Hellinga (1958), van de Leur Maasland (1958) and van Schilfgaarde (1965) equations. Average per cent deviations of predicted water table heights by Integrated Hooghoudt with instantaneous rise, Integrated Hooghoudt with rise factor, van de Leur Maasland, van Schilfgaarde and de Zeeuw Hellinga equations were 25.72, 16.71, 27.38, 27.20, 24.50 and 15.90% with corresponding RMSD of 0.2083, 0.2110, 0.1663, 0.2020, 0.1769 and 0.1779 for 50 m drain spacing plot and 15.90, 22.56, -28.54, -14.57 and 14.39% with corresponding RMSD of 0.1779, 0.2070, 0.2187, 0.1226 and 0.0911 for 75 m drain spacing plot, respectively. The approach for transforming a transient drain spacing equation to water table predicting equation in response to constant recharge is validated.

Key words: *Subsurface drainage, Drain spacing equations, Waterlogging, Salinity*

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DESIGN APPROACH OF ROOF TOP RAIN WATER HARVESTING STRUCTURE FOR DOMESTIC WATER SUPPLY IN RURAL INDIA

Chhedi Lal Verma[1], S.K. Jha[2], A.K. Singh[3], V.K. Mishra[4] and Rohit Pratap Ojha[5]

ICAR-Central Soil Salinity Research Institute Regional Research Station, Lucknow 226002 (UP)

Indian agriculture and domestic water supplies are heavily dependent on ground water. Groundwater over-exploitation has become a serious issue and a big challenge for planners. Based on the long term data of nearly 5,900 wells from 1996 to 2016, Central Ground Water Board (CGWB) concluded significant depletion in groundwater storage in majority of the districts of India. In Uttar Pradesh out of 820 blocks, 111 are overexploited, 68 critical, 82 semi-critical and 559 are categorized safe as per year 2011 data. Hand pumps are drying and failing during extreme summer. Water quality of the ground water is also becoming a serious issue in different pockets. Fluoride, arsenic, heavy metals, pesticides, nitrogen and chemical pollution is becoming a common problem. Drinking water in rural India is at a risk and needs immediate attention for safe supply. Rain water harvesting, storage and use could be seen as future solution of the problem to address various issues of water pollution.

Adaption of a predesigned roof top rain water harvesting structure for small roof top would be expensive or may not match the large roof top unless properly designed. Use of oversize pipe may increase the cost of the system while small size would allow water to stand over the roof for a longer time. Weight of standing rain water over the old roof top for longer period may not be desirable. Instant drainage from roof top may collect large volume of rain water not matching the recharge rate of the recharge unit if coupled with the ground water recharge system. Filtration requirement of the harvested rain water has to be assessed carefully prior to storage and use. Present study is devoted to develop design guideline of roof top rain water harvesting structure for individual roof. One day maximum rainfall depth expected in the region against a return period of 10 years was considered as design input data. For Lucknow region it was worked out as 140 mm. If the harvested rain water is to be used for ground water recharge maximum storage period of rain over the roof was considered as two hour. Older roof should be avoided for overloading due to rain water storage for large depth (<100 mm). Since the system is designed for one day maximum rainfall depth for 10 year return period, the ponding over the roof will not happen at all. For a roof top with an area of 66 m^2 against 144 mm one day maximum rainfall outlet size was calculated as 65 mm which could drain roof top within 0.67 hour. Only one outlet of size 65 mm is sufficient to drain the roof. A provision of bypass outlet was also suggested for emergency draining of the roof top. Conveyance pipe diameter was calculated as 25 mm only. To avoid clogging and ease in cleaning a matching diameter of 65 mm conveyance pipe could be recommended. Further analysis of runoff generation and outlet discharge at roof top indicates an increase in discharge rate initially but get stabilized after a period of 30 minute and remained stagnated up to 130 minutes and started declining thereafter drastically after cessation of rainfall. Water depth standing over the roof top with time also followed the similar suit. Water depth at the roof top after 30 minute got stabilized at a depth of 24.1 mm and started declining after 130 minutes. Thus depth of rain water which could be staying on the roof top is much less than the expected. A depth of 24.1 mm would add an additional load of 24.1 kg on one square meter roof.

Key words: *Design, Rain water harvesting, Domestic, Water supply*

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SERIOUS CONCERNS OF NATURAL GROUND WATER RECHARGE THROUGH SODIC SOIL

Chhedi Lal Verma[1], V.K. Mishra[2] and Rohit Pratap Ojha[3]

ICAR- Central Soil Salinity Research Institute Regional Research Station, Lucknow 226002 (UP)

Extreme climate events such as floods and droughts are disastrous and affect Indian economy. Declining ground water level with increasing pumping scenario with coupled global warming is becoming continuously a great threat to Indian agriculture and economy. Glaciers are shrinking and water table are steeply declining resulting to continuous decrease in stream base flows and are at the verge of becoming discrete. Intensive cropping and growing industrial and domestic demand for good quality water is further growing in the region. Induced or managed ground water recharge is still under debate arena. Natural recharge of ground water is still key factor governing the status of ground water reserve of the area. As a thumb rule 10 to 15% of the rainfall of the area is converted into ground water under normal soil conditions. Uttar Pradesh has vast river plains and ground water aquifers and heavily relies on ground water for agriculture and domestic needs. Sources say that 0.80 million hectare of sodic soil out of 1.37 million hectare have been reclaimed and put under agriculture. Ground water uses in sodic area have increased several folds with much restricted natural recharge rate. Ground water recharge rate is governed by the basic infiltration rate of the root zone. An analysis was done to study the reduction in relative hydraulic conductivity of the soil which is the ratio of the saturated hydraulic conductivity against sodic condition to the saturated hydraulic conductivity of the normal soil. Saturated hydraulic conductivity at soil pH of 8.0 ($pH_{1:2}$ = 8.5) remains unaffected while with an increase of one unit i.e. at $pH_{1:2}$ of 9.5 there is a reduction of nearly 87% in the saturated hydraulic conductivity. Thereby meaning that recharge rate at soil pH of 9.5 is less than 87% compared to the normal soil having $pH_{1:2}$ 8.5.

Currently, in India, about 60 per cent of the cultivated area is irrigated by groundwater. This indicates that as groundwater over-exploitation became severe, agricultural production declined and the overall economic future of regions became uncertain. The Indo-Gangetic Plain, northwestern, central and western parts of India account for most intensive groundwater based irrigation and among these regions, western India and the Indo-Gangetic Plain have more than 90% of the area irrigated using groundwater. Based on Central Ground Water Board (CGWB) data of nearly 5,900 wells which have long-term data (1996–2016) found that a majority of districts in India experienced significant depletion in groundwater storage. Districts with significant decrease in groundwater are located in the Indo-Gangetic Plain. In Uttar Pradesh out of 820 blocks, 111 are overexploited category, 68 critical, 82 semi-critical and 559 are safe as per year 2011 data. If groundwater depletes and the region experiences drought for two to three years consecutively, there will be serious challenges. Availability of even drinking water will be a huge problem. Natural recharge during monsoon under sodic soil may not help much if groundwater depletion becomes acute due to extremely low infiltration rate of the surface soil. Managed aquifer recharge seems to be the only solutions in such area. Government attention is invited to address the issue at the earliest.

Key words: *Ground water, Recharge, Sodic soil*

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SOIL HYDRAULIC CONDUCTIVITY AS A FUNCTION OF EXCHANGEABLE SODIUM PERCENTAGE (ESP)

Rohit Pratap Ojha[1], Akhilesh Kumar Tiwari[2], Manjul Kumar[3], Chhedi Lal Verma[4] and Maneesh Pandey[5]

[1]Senior Research Fellow, CSSRI RRS, Lucknow,[2]Senior Research Fellow, CSSRI RRS, Lucknow,[3]Research Scholar, SHUATS, Allahabad,[4]Senior Scientist, CSSRI RRS, Lucknow, [5]Senior Technical Astt. ICAR-CSSRI, RRS, Lucknow

Hydraulic conductivity of the soil is an important parameter extremely useful in understanding the movement of water and gasses within porous medium of soil. Design of irrigation and drainage systems, natural or induced recharge studies, ground water movement and studies on movement of pollutants require the knowledge of saturated as well as unsaturated hydraulic conductivity of the soils. The hydraulic conductivity of the soil is mainly dependent on soil texture, structure, organic matter and salt composition of the soils. The presence of high organic matter in the soil provides stable structure to the soil maintaining good tilth and density. There are numerous in-situ and laboratory methods to measure hydraulic conductivity of the soil. Infiltrometer, auger and inverse auger hole methods are quite common method for *in-situ* measurement of saturated hydraulic conductivity. Disc permeameter, surface and subsurface point source dripper methods have been also employed for *in-situ* measurement of unsaturated hydraulic conductivity. Presence of excessive salts in the soil affects the water transmission characteristics of the soil. There are two types of salts, neutral electrolyte salts such NaCl and Na_2SO_4 and basic salts such as Na_2CO_3 and $NaHCO_3$. Excessive presence of Na_2CO_3 and $NaHCO_3$ in soil makes it sodic by increasing pH and ESP. Both the parameters are actually correlated. High ESP disperses the soil aggregates and chokes the pore reducing the water transmission capacity of the soil. Uttar Pradesh once had 1.37 million hectares of sodic soil out of which 0.80 million hectare is reclaimed. Water movement through barren or partially reclaimed sodic soil is important for leaching and recharge studies as well as soil and plant health. Sodic soils are often characterized by the high pH of its saturated extract (>8.5) and high exchangeable-sodium-percentage (>15 milli equivalent per 100 gram of soil). Adsorption of sodium and potassium cations on the exchange complex of soils often leads to clay dispersion, swelling, flocculation, and adverse effects on soil physical properties. Saturated hydraulic conductivity and infiltration rates of soils have been observed to be influenced by the sodium adsorption ratio, pH, and salt concentration of the saturated extract (Abrol *et al*., 1985). Abrol *et al*. (1985) have presented a graphical relationship (scaling factor) between the exchangeable sodium percentage (ESP) and relative hydraulic conductivity. Graphical relationship has limited application. Present study is devoted to change the graphical relationship into the equation for its wide application. The relative hydraulic conductivity ($K_r=K_{ESP}/K_N$) which a measure saturated hydraulic conductivity under a level of exposed ESP (K_{ESP}) to the hydraulic conductivity of the soil under normal conditions (K_N) was worked out by fitting the data of Abrol *et al*. (1985) to large numbers of the standard functional relationships. Richards, Gaussian, Polynomial, Sinusoidal, Quadratic, Modified Power and Exponential forms of relations could predict the behavior of the curve. The Richards Equation described the variations of K_r with ESP ($K_{r(ESP)}$) in a best way with r=0.9995991 and S=1.30934765. The following equation is recommended for further use in the modeling and field applications.

$$K_{r(ESP)} = \frac{100}{\left(1+\exp\left(0.48467735ESP - 4.3451747\right)\right)^{\frac{1}{4.7746612}}}$$

The above equation takes following form for describing reduction in saturated hydraulic conductivity of soil against soil pHs with r= 0.99731456 and S=3.17132071.

$$K_{r(pH_s)} = e^{5206.5059 - \frac{13382.768}{pH_s} - 1697.153 \ln pH_s}$$

Key words: *Hydraulic conductivity, sodic soil, infiltration, functional relationships*

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ARTIFICIAL NEURAL NETWORK MODEL FOR VALIDATION OF PREDICTED EVAPOTRANSPIRATION

S.K. Singh[1*] and Chhedi Lal Verma[2]

[1]Principal, Government Polytechnic, Department of Technical Education, UP, India. [2] Senior Scientiste, Central Soil Salinity Research Institute, Regional Research Station, P.O. Dilkusha, Lucknow-226005(UP), India.
**Corresponding author email: adsksingh@gmail.com*

A feature based Artificial Neural Network (ANN) model was developed for validation of predicted Evapotranspiration (ET) of eucalyptus. Six weather parameters namely maximum temperature, minimum temperature, relative humidity first, relative humidity second, wind velocity and sunshine hour were used by the ANN model. Artificial neural network of seven neurons in the input layer, two hidden layer with 28, 14 neurons and only one neuron in the output layer is the optimum network based on present data set (7, 28, 14,1) structure to simulate the ET for growing eucalyptus in response to weather parameters. The estimates of daily ET by ANN model were close to the values of ET observed by analytical model. The proposed ANN model captures the seasonal as well as annual variation of ET with present data set. ET by the ANN model and observed values by analytical model are quite close to each other. A regression coefficient (r^2) were obtained 0.9749 for training, 0.9526 for testing, 0.9624 for validating and 0.9696 for overall data, indicating good learning and generalization by the network. The performance of ANN Model can be attributed to its structural and functional characteristic, such as the nonlinear model capability and the universal function approximation.

Key words: *Artificial Neural Network, Back propagation algorithm, Evapotranspiration*

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TRANSFORMING WATER TABLE HEIGHTS OF HORIZONTAL SUBSURFACE DRAINAGE OF FLAT LAND TO SLOPING CONDITIONS

Gyan Singh[1], Chhedi Lal Verma[2] and D.M. Denis[3]

[1.&3]Ph.D. Scholar and Professor & Head, Irrigation and Drainage Engg., SHUATS, Prayagraj,[2]ICAR Central Soil Salinity Research Institute, Regional Research Station, Lucknow

Reclamation and management of waterlogged with or without salt accumulation on flat land through subsurface drainage is a common practice over the globe. The aim of subsurface drainage is to maintain water table at depth optimum for the climate, crop and soil allowing leaching of harmful salts. Water table fluctuations between the drains or ditches depend on the duration and replenishment rate. Most of the theories deal with water table fluctuation in response to constant recharge for flat lands. Drainage theories for sloping land need more attention. Boussinesq equation had been used for developing analytical solutions for horizontal as well as sloping land. The present study is focus to understand the drainage

pattern of sloping land using the drainage theory of horizontal subsurface drainage. The experimental data of a Hele-Shaw model of length 1.84 m and height 0.56 m for 0, 0.026, 0.052 and 0.078% bed slopes was utilized for present study. The spacing between plates was kept as 1.65 mm. Shell Tellus oil 72 was used as viscous fluid with density ranging from 475.000 to 2218.75 centipoise and corresponding bulk density range as 0.9480 to 0.9655 g cm^{-3} for a temperature range of 40 to 20°C. A linear relationship between water table reduction factor and horizontal distance was observed. The variable error correction factor of and fixed error correction factor as a function of bed slope was worked out to calculate total error correction factor for changing steady state water table heights between the horizontal and sloping impervious barrier to the sloping conditions as below. Comparisons were made between predicted water table heights using analytical solution of Sewa Ram et al. (1987) and proposed model. The proposed model predicted closer values of water table heights with root mean square deviation (RMSD) of 0.161744, 0.181304 and 0.166229 while analytical model could predict water table heights with RMSD of 0.824461, 1.039384 and 0.909310 against the slope of 0.078, 0.052 and 0.026%, respectively. The proposed model is easy to understand the subsurface flow problem of horizontal subsurface drainage in relation to the subsurface drainage of sloping lands with suggested correction.

Key words: *Subsurface drainage, Sloping land, Waterlogging, Salt accumulation*

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DOUBLING FARMERS' INCOME THROUGH INTEGRATED FARMING SYSTEM APPROACHES IN PRATAPGARH

A.K. Singh[1], P.K. Upadhyay[2] and A. Baranwal[3]

[1]Scientist, KVK, Pratapgarh, UP-229408, [2]Program Assistant, KVK, Pratapgarh, UP-229408, [3]Scientist, KVK, Pratapgarh, UP-229408

Indian agricultural scenario is highly influenced by the traditional norm which support the subsistence farming as well as their livelihood. In case of Uttar Pradesh, farming community is categorized in three categories small, marginal and large farmers, among these marginal farmers are dominating in numbers. In UP operating marginal holdings is often unviable and in this situation, farming is not a profitable business or enterprise. In the recent scenario, Pratapgarh comes under water stress districts of the UP and some other major challenges and issues in agriculture are timely unavailability of quality seeds, quality fertilizers, irrigation facility, lack of appropriate marketing facility, less storage and processing facilities etc. Therefore, there is an urgent need of transformation in agriculture production combined with integrated farming system (IFS) approaches that involves crop cultivation, dairy farming, poultry farming, fishery, mushroom cultivation, agro-forestry, pig farming, bee keeping, vegetable and fruit production, off season vegetable production, use of renewable energy source (i.e. Solar energy, Biogas) etc. There is a need of important strategies for doubling of the farmer's income. These strategies might be game changer in agricultural research and development, adoption of Good Agricultural Practices (GAP), conservation agriculture technology, implementation of farmers based policies, judicious use of available natural resources and inputs, along with improved market facility, minimum support price (MSP) reform, supported by adequate and timely availability of bank credits. Climate smart agriculture is other possible strategies in doubling farmer's income. When we talk about diversification, it mostly deals with high value crops and value addition. In terms of economic and socio-ecological aspects we need to sustain the production which is ensured by adopting integrated farming system approach

Key words: *Beekeeping, Agriculture, Sustainable, Farmers*

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FERTILITY AND BREEDING EFFICIENCY INCREASE THE DAIRY ANIMAL PRODUCTION

Ashish Srivastva and Manoj Kumar Singh

Krishi Vigyan Kendra, Kaushambi

Reproduction is an important consideration in the economics of cattle production. In the absence of regular breeding and calving at the appropriate time, cattle rearing will not be profitable. The efficiency of reproduction in farm animals depends on various factors, such as both genetic and non-genetic factors, the non- genetic factors being climate, nutrition, and level of management. The genetic factors are such as age of attainment of puberty, length of sexual season, frequency of estrus occurrence, number of ovulation, gestation period, litter size, suckling period, reproductive disoders, hormonal imbalance and length of normal reproductive life of the animals. Successful reproduction means the ability to mate, the capacity to conceive and to nourish the embryo and deliver the viable young ones at the end of a normal gestation period. In fact, interruption in this chain of events leads to proper heat failure of the animal either to conceive or the embryo to die or to have a premature delivery of the foetus called anoestrus and abortion in animals.

Under the reproductive disease threat KVK, Kaushambi conducted a trail for dairy farmers those suffered from such condition. Under this trail 50 animals (22 cows and 28 buffaloes) were screen out under normal farm condition, in these animals has reproduction failure (ovarian inactivity and heat signs) and managemental (nutritional and poor body condition) defects. Treatment options for animals include hormonal and management strategies. Before trail per rectal examination (uterine palpation and infusion of Lugol's solution) and dewormer drug (3gm) given to all selected animals after that animal treated with hormonal therapy (progesterone supplementation- 3ml IM), result in the majority of estrous synchronization effect, thus facilitating the use of artificial insemination estrus on good heat (19 cow – 86.36% and 23 buffaloes- 82.14% were shown positive) with a subsequent luteal phase of normal duration and improved pregnancy rates compared with untreated control.

There is undoubted biological advantage in treating anovulatory anestrous animals in many production systems, the economics of such interventions remain to be elucidated. Costs of instituting treatments include drug, labor, veterinary input, and opportunity costs. Potential benefits include shorter inter-calving intervals, reduced culling of nonpregnant cows, and improved labor efficiency related to reduced time spent on estrous detection and calving observations. The economics of reproductive performance is complex as it affects breeding costs, culling, and replacement rates, feed costs, and utilization, as well as milk production.

Key words: *Fertility, Breeding efficiency, Dairy animals*

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PREDICTION OF RICE WATER REQUIREMENT USING FAO-CROPWAT MODEL IN DEHRADUN, UTTARAKHAND

Ramesh Verma* and R.M. Singh

Deptt. of Farm Engg. I.Ag. Sc., Banaras Hindu University, Varanasi-221005, U.P
**Corresponding author email: ramesh.verma126@gmail.com*

Insufficient water supply is one of the most important factor governing agricultural productions. In addition to rainfall, a thorough knowledge of seasonal values of evaporation and crop transpiration, runoff, deep drainage and soil water storage is required to estimate the water need of crop. Water management is crucial to rightly offer and economize on water use in improvement of rice productivity. This paper aims to estimate Rice water requirement and irrigation water requirement in Dehradun district, based on the New Loc_Clim projected meteorological data. Rice water requirements are estimated by using crop coefficient approach. Reference evapotranspiration are calculated by FAO Penman-Monteith method. Moreover, the irrigation water requirements are simulated by calibrated CROPWAT model using the meteorological parameters.

Key words: *FAO-CROPWAT, Evapo-transpiration, Effective Rainfall*

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EVALUATION OF DROUGHT CHARACTERISTICS BASED ON RAINFALL PATTERN FOR KEN-BETWA BASIN

Gaurav Sharma* and Ankit Kumar

National Institute of Hydrology, Central India Hydrology Regional Centre, Bhopal-462 016, Madhya Pradesh
**Corresponding author email: ergksh@gmail.com, ankitkumarchitrakoot@gmail.com*

In the present scenario rainfall based drought characteristics is important to critically assess the spatial and temporal pattern of drought which gets subsequently affected due to climate change and global warming. The extent and behaviour of drought is unpredictable and unprecedented but through authentic long term data source of rainfall its behaviour can be predicted to some extent. The average annual rainfall for basin is 1071 mm. Jalaun district receives much lesser rainfall than basin average. The magnitude of rainfall decreases as moving from south to North in the basin. The rainfall variability in the region is quiet high (CV=30) and one of the reasons for frequent occurrence of drought in the region. Sagar district has maximum rainfall variability (CV= 54) compared to other district. Based on rainfall departure analysis 1981, 1984, 1997, 2000, 2010 and 2012 are drought years indicating severe impact of drought due to rainfall variability and climate change. Using Relative departure Index prioritization of district has been carried out based on which mitigation and relief activities are provided to district based on their ranking. Drought assessment helps in implementation of drought mitigation strategies and planning to cope under such situation. It not only helps in proper channelization of mitigation activities but also help in adopting conservation practices that help to reduce the impact of drought. Due to increase in population and overexploitation of natural resources the frequency of occurrence of drought increases therefore suitable measures should be adopted by government agency and different stakeholders to cope under such situation and strict policy are to be adopted for natural resource management and its conservation.

Key words: *Coefficient of Variance, Rainfall departure, Relative departure Index*

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A COMPARATIVE STUDY FOR MAPPING OF RAVINES USING HIGH RESOLUTION SATELLITE DATA

Poonam Varshney*, M.S. Yadav, B. Lal and Alok Mathur

Remote Sensing Applications Center UP, Sector-G, Jankipurum, Kursi Road, Lucknow, Uttar Pradesh, India

** Corresponding author email: poonam_140881@rediffmail.com*

Study has been carried out to map the areas with erosion using remotely sensed data from Indian Remote Sensing (IRS) satellite LISS IV (Resourcesat-2) & CARTOSAT Sensor. Remotely sensed data provide timely, accurate and reliable information on degraded lands at definite time intervals in a cost effective manner. Geographic Information System (GIS) have augmented the efficiency of soil survey. The management of resources on sustainable basis emphasize the overall development of the region without diminishing the environment. The integrated use of advanced computer technologies with database can be used to assist decision makers for future plans.

The merged satellite data Cartosat + LISS IV (2.5 m resolution) and LISS IV (5.8 m resolution) data covering 2 project village for the mapping of ravenous categories at cadastral level .Mapping of ravenous area with the help of high resolution satellite data the following units are mapped T- Table Land (Slope < 1%), P- Pere feral Land (Slope 1-5%), Shallow Ravine (R1) (Slope < 5%), Medium Ravine (R2) (Slope <10 %) and Deep Ravine (R3) (Slope >10%), Flood Plain (FP), Dense Forest (F1, > 30% Canopy), Medium Forest (F2 ,10-30 % Canopy), Poor Forest (F3 <10% Canopy), VB/FP Cultivated Valley Bottom.

For the delineation of different categories/ units in the mapping of project villages through Cartosat + LISS IV Merged Data (2.5 m resolution) was most suitable in comparison to LISS IV (5.8 m resolution) in cadastral level. The different categories/ units easily mapped, for the application of different soil conservation measure and agricultural practices in different units.

Key words: *GIS, High resolution Data, Remote Sensing, Soil resource mapping*

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SUGGESTIVE ARTIFICIAL RECHARGE STRUCTURES IN HARD ROCK TERRAIN AREAS FOR SUSTAINABLE GROUNDWATER CONSERVATION USING REMOTE SENSING, GIS AND GEOPHYSICAL TECHNIQUE

V.J. Ganvir[1*], Kaushlendra Singh[2], Aniket Khare[3], Pushpesh Kumar[4] and Mamta Yadav[5]

[1]Scientist- SE & Head GWRD, Remote Sensing Applications Centre, Lucknow UP

[2]Scientist-SD, SRD Division, Remote Sensing Applications Centre, Lucknow UP

[3]Student M. Tech (RS & GIS), Remote Sensing Applications Centre, Lucknow UP

[4]Project Scientist, Remote Sensing Applications Centre, Lucknow UP

[5]Project Scientist, Remote Sensing Applications Centre, Lucknow UP

**Corresponding author email: vinitjganvir@gmail.com, drksinghr@gmail.com*

The rapidly increasing need for water has put huge stress on groundwater resources in areas having groundwater as prime source of water. Due to improper extraction of groundwater without maintaining the balance with the recharging of the existing aquifer system, this problem will furthur aggravate.

Artificial groundwater recharge is becoming increasingly necessary, as growing population require more water and moreover conversion of runoff water into ground water is needed during rainy season for use in time of shortage or non-rainfall days.

In view of the above, Mandwara block of Lalitpur district, UP has been undertaken for the present study because it is a hard rock terrain area of Bundelkhand region, where surface water bodies dry in summer season and the habitants are mostly dependent on groundwater for irrigation and domestic purposes. Agriculture is the main source of income in this region and maximum irrigation is done through groundwater only. Survey of India toposheets and IRS P6 LISS IV satellite imagery of the year 2009 have been utilized to prepare various thematic layers viz. drainage, lineament, geomorphology and Land use/ Land cover map. SRTM 30m imagery has also been used to assess general runoff direction of the area and to prepare slope map of the study area. Using Geophysical technique i.e. vertical electrical survey were conducted at 20 sites to collect sub surface lithological information, identification of horizontal and vertical disposition of aquifer system and also for recommendation of suitable artificial recharge structure for conservation of water during rainy season. Collected overburden thickness and aquifer layer thickness maps have been prepared through GIS techniques. All the thematic layers are exported to ArcGIS and different combinations were used to suggest various artificial recharge structures like check dam, Nala bund, distillation of pond, percolation tank and recharge pit for the conservation of water at suitable sites of the study area. All thematic layers were integrated into GIS platform in order to get the artificial recharge zonation map and it was further categorized into four different zones, namely most favorable, moderately favorable, favorable and least favorable site for the selection of artificial recharge structure in the present study area. Thus the above study has clearly shown the capabilities of Remote sensing, GIS and Geophysical technique to achieve the sustainable groundwater level in areas having similar geology and climatic conditions.

Key words: *Artificial groundwater recharge, Hard rock terrain, Satellite imagery, Remote sensing, GIS and Geophysical technique, Arc GIS, Sustainable groundwater level*

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LEVEL OF SOIL ORGANIC CARBON FRACTIONS AS AFFECTED BY LONG TERM EFFECT OF FERTILIZATION AND MANURING IN ALFISOL ORDER OF INDIA

Vandana Kumari* and T.J. Purakayastha

Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi 110 012, India
**Corresponding Author email: vandana.iari16@gmail.com*

Photosynthesizing vegetation takes up carbon dioxide and sequesters it as biomass carbon in the terrestrial carbon pool. Therefore, soils play a major role in maintaining a balanced global carbon cycle. Soil organic C (SOC) storage may be increased directly by increasing C returns to the soil as crop residue, manure, or other organic amendments. As interest increases in both promoting organic C storage, it is crucial to understand the relative stabilization efficiency of added residue C as well as its stability in the soil. Optimum levels of soil organic matter (SOM) can be managed through crop rotation, fertility maintenance including use of inorganic fertilizers and organic manures, tillage methods, and other cropping system components. The carbon can be sequestered in soil by various physical, chemical and biochemical means. Among these management practices, proper cropping systems and balanced fertilization are believed to offer the greatest potential for increasing SOC storage in agricultural soils. In order to address the above issues, soil samples were collected (0"30 cm depth) from long-term field experiment, which is in progress since 1983-1984 at Ranchi (Alfisol). The SOM fractions, such as water

extractable organic matter C and nitrogen (WEOM-C &N) and labile pool –I and II of acid hydrolysable SOC are reported for being a component of the labile SOM and also being closely related to soil microbial biomass and micro-aggregation could therefore be used as one of the soil quality indicators and that of phenol, recalcitrant pool, aromaticity in DOC in soil–plant ecosystems. Our results revealed that in Alfisol, at 0-15 cm soil depth, treatment 50%NPK+50%N-FYM showed higher soil organic C (SOC). T1 (control) showed the least amount of SOC. The SOC content at 15-30 cm depth was highest in 50%NPK+50%N-CR. Water extractable organic matter carbon and nitrogen (WEOM-C and WEOM-N) was highest in 50%NPK+50%N-GM for in both the soil depths. Aromaticity in dissolved organic carbon (DOC) was highest in (50%NPK+50%N-GM) for Alfisol in both the soil depths. H_2SO_4 hydrolysable Labile I+II was highest in 50%NPK+50%N-GM but recalcitrant pool of SOC was highest in the control treatment in Alfisol in both depths. The phenol content was higher in 50%NPK+50%N-GM in Alfisol. The initial SOC stock at 0"60 cm soil depth in the year 1983 was 42 Mg ha^{-1} in Alfisol respectively. The SOC stock in the year 2014 was observed highest in 50%NPK+50%N-FYM in Alfisol.

Key words: *Soil organic carbon, Labile pool, Recalcitrant, Dissolved organic carbon (DOC)*

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CARBON SEQUESTRATION IN SOIL FOR SUSTAINABLE AGRICULTURE IN CHANGING ENVIRONMENT

Kumar Anshuman[1], Gajraj Yadav[1], Sandeep Yadav[1] and Nishakant Maurya[2]

[1]Research Scholar, Soil Science and Agril. Chemistry, [2]Research Scholar, Vegetable Science, A.N.D.U.A. & T., Kumarganj, Ayodhya (UP)

Soil carbon sequestration is a strategy to achieve food security through improvement in soil quality. The carbon sink capacity of the world's agricultural and degraded soils is 50 to 66% of the historic carbon loss of 42 to 78 Gt of carbon. The rate of soil organic carbon sequestration with adoption of recommended advanced technologies depends on soil texture and structure, rainfall, temperature, farming system, and soil management. Strategies to increase the soil carbon pool involve soil restoration and woodland regeneration, no-till farming, cover crops, nutrient management, manuring and sludge application, improved grazing, water conservation and harvesting, efficient irrigation, agroforestry practices, and growing energy crops on spare lands. Various study showed that an increase of 1 ton of soil carbon pool of degraded cropland soils may increase crop yield by 20 to 40 kilograms per hectare (kg/ha) for wheat, 10 to 20 kg/ha for maize, and 0.5 to 1 kg/ha for cowpeas, as well as enhancing food security, carbon sequestration has the potential to offset fossil fuel emissions by 0.4 to 1.2 gigatons of carbon per year, or 5 to 15% of the global fossil-fuel emissions. The global soil carbon (C) pool of 2500 gigatons (Gt) includes about 1550 Gt of soil organic carbon (SOC) and 950 Gt of soil inorganic carbon (SIC). The soil C pool is 3.3 times the size of the atmospheric pool (760 Gt) and 4.5 times the size of the biotic pool (560 Gt). The SOC pool to 1^{-m} depth ranges from 30 tons/ha in arid climates to 800 tons/ha in organic soils in cold regions, and a predominant range of 50 to 150 tons/ha. The SOC pool represents a dynamic equilibrium of gains and losses. Soil carbon sequestration is a strategy to achieve food security through improvement in soil quality. It is a by-product of the inevitable necessity of adopting recommended management practices for enhancing crop yields on a global scale. While reducing the rate of enrichment of atmospheric concentration of CO_2, soil carbon sequestration improves and sustains biomass/agronomic productivity. It has the potential to offset fossil-fuel emissions by 0.4 to 1.2 Gt C/ year, or 5 to 15% of the global emissions. Soil organic carbon is an extremely valuable natural resource. Irrespective of the climate debate, the Soil organic carbon stock must be restored, enhanced, and improved. A carbon management policy that includes regulation-based trading soil carbon must be developed.

Likewise, a widespread adoption of recommended management practices by resource poor farmers of the tropics is urgently warranted.

Key words: *Carbon sequestration, Organic, Nutrients, Food security, Soil restoration*

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CROP REGULATION IN POMEGRANATE FOR QUALITY AND HIGHER FRUIT PRODUCTION

Jitendra Singh Shivran[1*], Mohan Lal Jat[2] and R. K. Jat[3]

[1]Department of Horticulture, College of Agriculture, GBPUA &T, Pantnagar, [2]Department of Horticulture, College of Agriculture, CCS HAU, Hisar
[3]Department of Fruit Science, College of Horticulture, SDAU, Jagudan, Gujarat
**Corresponding Author email: jitendrashivran@gmail.com*

Pomegranate bears different flowering flushes throughout the year if left without any treatment. It primarily shows three distinct flowering seasons *i.e.* February-March (*Ambe Bahar*), June-July (*Mrig Bahar*) and October-November (*Hasta Bahar*) with the corresponding harvest period during rainy (June – July), winter (November- December) and spring season (February- March), respectively. Secondly, Three types of flowers namely male, hermaphrodite and intermediate are borne on new and old branches in pomegranate for once, two or three times in a year that are influenced by germplasm, climate and management practices *etc*. It gives poor quality and low yield at different times and is not commercially profitable. Good quality and higher yield can be achieved by long-term use of limited cultivation resources at the desired time by crop regulation in pomegranate. In order to escape this, crop regulation in pomegranate is done keeping in mind the availability of irrigation, pest and disease infestation and market prices.

Key words: *Crop regulation, flowering, yield and quality*

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INTEGRATED FARMING SYSTEM FOR DOUBLING FARMERS' INCOME

[1]Gajraj Yadav, [1]Sandeep Yadav, [1]Kumar Anshuman, [1]Rahul Ranjan and [2]Nishakant Maurya

[1]Research Scholar, Soil Science and Agril. Chemistry
[2]Research Scholar, Vegetable Science
A.N.D.U.A. & T., Kumarganj, Ayodhya (U.P.)

In India, the farmers maintain different enterprises for their complimentary and supplementary nature and for ensuring sustainable livelihood from time immemorial. After the advent of green revolution in late-1960s and economic liberalization in early-1990s, the farmers gradually started focusing on a few enterprises due to several imposing factors including shrinking farm sizes, fluctuating commodity prices, livelihood diversification and shortage of labour during peak agriculture season. It had a severe impact on food and nutritional security of millions of poor farm households. The anguish of farmers is often expressed in terms of their agitation in one or the other part of the country, unwillingness to continue farming and increasing demands of compensating their economic loss. Although suggestions are pouring in from experts and leaders of organization for strengthening the income base of farmers, the government cannot implement them entirely due to compulsions from socio-economic and political considerations. However, the Government of India has made an announcement about Doubling Farmers' Income by

2022. Experts are judging the options and strategies for achieving this enviable target. One of the options is to evaluate the potential of age-old integrated farming system (IFS) in enhancing income of farm families within the reasonable time period. "A small farm (up to 2 hectares) holds the key to ensuring food and nutritional security of India and therefore, location specific integration of field crops, orchard, floriculture, agro-forestry on one hand and dairy, poultry, piggery, fishery on the other is the answer", said Union Agriculture Minister.To highlight the Economic Survey of India 2017-18 which indicated that over a period of 10 years, the share of income of farmers from crop production increased by only 1% while it increased by 7% for livestock, Minister called upon additional avenues for farmers.Scientifically designed Integrated Farming Systems (IFS) is being promoted to achieve the target of doubling farmers' income by 2022.

The intentional integrated systems are one which addresses the multiple objectives of increased production, profit, cost-reduction through recycling, family nutrition, sustainability, ecological security, employment generation, economic efficiency and social equity. Expressing happiness, ICAR has partnered with 25 State Agricultural universities (SAUs), 5 research institutes and 1 Central University through All India Co-ordinated Research Project (AICRP) and developed 45 Integrated Farming System (IFS) models suitable to 23 states and 1 Union Territory for providing better production and income.

Key words: *Integrated farming system, Farmers doubling income, Government strategies*

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EFFECT OF DIFFERENT TYPES OF MULCHING ON GROWTH, YIELD, QUALITY AND ECONOMICS OF BRINJAL (*Solanum melogena*) UNDER BUNDELKHAND REGION OF U.P

Prashant Kumar[1*], Shalini[2], Md. Mustafa[3], Somvanshi[4] and Chanchal Singh[5]

[1, 2, 4, 5]SMS and [3]Sr. Scientist cum Head, Krishi Vigyan Kendra, Hamirpur*
**Corresponding Author email: prashantbhu1984@gmail.com*

Mulching is important factor for proper growth of plant, increases the production and productivity crop. The major advantages of using mulching in brinjal crop are water conservation, weed control, early crop production and high yield. An experiment was conducted by Krishi Vigyan Kendra, Hamirpur at farmer's field during the year 2018-19 on the effect of different types of mulching on growth, yield, quality and economics of Brinjal (*Solanum melogena*) under Bundelkhand region of Uttar Pradesh. Experiment was conducted in randomized block design with five treatments viz; Black polyethylene mulch (T_1), Chickpea straw mulch (T_2), Pea straw mulch (T_3), Lentil straw mulch (T_4) and no mulch (control) (T_5).The result reveled that the maximum plant height (115.0 cm), no. of primary branches (07) were observed in T_1 while minimum plant height and primary branches was recorded in T_5. Significant effect for yield parameter the maximum number of fruit per plant (38), fruit length (8.4 cm), fruit width (7.8 cm), average fruit weight (75 g) and yield (351.83q/ha.) was recorded in T_1, while, minimum yield was recorded (169.74 q/ha.) in T_5. Minimum days taken to 50 percent flower initiation (42 days) T_1 fallowed by (58 days) T_2 and (57 days) T_3. On the basis of observations the black polyethylene mulching is beneficial technique to minimize the competition between crop, weed and water stress during the period of crop production. The maximum net return of Rs.2,15,800.00 was calculated in treatment T_1 as compared to other treatments in this experiment during 2018-19.The benefit-cost ratio was highest (3.32) with black polythene mulch as compared to control

Key words: *Black polythene mulch, Straw mulch, Water stress, Brinjal*

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FORMS OF IRON ASSOCIATED WITH CLAY FRACTION AND THEIR DISTRIBUTION IN PADDY AND ASSOCIATED NON-PADDY SOILS OF ASSAM

Shraddha Mohanty[1*], R.M. Karmakar[2] and Veena Bharati[3]

[1]Department of Soil Science & Agricultural Chemistry, OUAT, Bhubaneswar-751003, Odisha, [2]Department of Soil Science, Assam Agricultural University, Jorhat-785013, Assam, [3]Department of Agronomy, BAU, Sabour, Bihar
[*]Corresponding author email: shraddha.mohanty001@gmail.com

Profiles of paddy and associated non-paddy soils of Jorhat (P1, NP1), Golaghat (P2, NP2), Sivasagar (P3, NP3) and Dibrugarh (P4, NP4) districts of Assam were investigated for different fractions of iron (Fe): total (Fe_t), dithionite extractable (Fe_d), pyrophosphate extractable iron (Fe_p) and oxalate extractable iron (Fe_o) in the clay fraction of soil. Irrespective of the different fractions of Fe present, total (Fe_t), dithionite extractable (Fe_d), pyrophosphate extractable iron (Fe_p) in clay fraction were slightly higher in non-paddy soils as compared to paddy soils whereas oxalate extractable iron (Fe_o) showed a reverse trend. Fe_d formed major portion of total iron content in clay fraction (Fe_t) followed by Fe_o and Fe_p in both paddy and non-paddy soils. Crystalline iron oxide (Fe_d-Fe_o) and silicate iron (Fe_t-Fe_d) in clay fraction was found to be higher in non-paddy soils while amorphous inorganic form of iron (Fe_o-Fe_p) showed the reverse trend. Also, irrespective of the land use, the contents of different forms of Fe in the clay fraction were higher in the illuvial B horizon due to presence of higher amount of clay. Fe_d/Fe_t was found to be higher in non- paddy soil than that of paddy soil. The active iron ratio (Fe_o/Fe_d) was higher in the surface horizon as compared to other horizons of a profile. Different fraction of Organic carbon and the content of clay had a strong influence on the distribution of forms of Fe in the clay fraction of soil. The results also revealed that there was equilibrium in different fractions of this element.

Key words: *Dithionite extractable, Pyrophosphate extractable, Oxalate extractable, active iron ratio, Illuvial B horizon*

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ORGANIC FARMING OF VEGETABLES: PROSPECTS AND SCENARIO

Rajesh Choudhary[1] and Manisha Dhayal[2]

[1]Department of Horticulture, SKNAU-Jonber, [2]Department of vegetable Science, CH & F, Jhalawar
**Corresponding author email: ashokchoudhry116@gmail.com*

The success rate of organic farming in some countries is due to the high awareness of health problems through the consumption of contaminated food products, the harmful effects of environmental degradation, appropriate supports government and organizations like the European Union and the International Federation of Organic Agriculture Movements (IFOAM). Conventional farming had helped India not only produce enough food for its own consumption, but also generated surpluses for exports. However, the increase in population and income will further increase the demand for food and also for raw materials for industry. The modern agricultural system, we feel more and more, is becoming unsustainable and as evidenced by declining crop productivity, environmental damage, chemical contamination, etc. The necessity of an alternative farming method that can work in a friendly ecosystem while supporting and increasing the harvest productivity is now achieved. Organic farming is recognized as the best known alternative to conventional farming. The main weaknesses of organic farming in the country are the lack of links between farmers and markets and the absence of financial support from

governments. India has the potential to become a large producer of organic products in view of international demand for our agricultural products, different agro-climatic regions for growing a number of crops, the size of the internal market and above all the long tradition of agriculture and life respectful of the environment.

Key words: *Envireonmental degradation, Conventional farming, Organic farming*

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UP-SCALING OF UNDERGROUND TRANSFER OF FLOOD FOR IRRIGATION (UTFI): AN INNOVATIVE APPROACH OF CONJUNCTIVE WATER USE MANAGEMENT IN RAMPUR DISTRICT OF UTTAR PRADESH, INDIA

Navneet Sharma[1*], Mohamad Faiz Alam[1], Alok Sikka[1] and V. K. Mishra[2]

[1]International Water Management Institute, New Delhi, India, [2]ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow, India

**Corresponding author email: navneetsharma.mit@gmail.com*

Rampur district is situated in the north-western part of Uttar Pradesh, and is typical of the Indo-Gangetic Plain. About one-third of the total GDP of the district is based upon agriculture and animal husbandry, and almost half of the total workforce work in agriculture, reflecting a strongly agrarian community. Paddy and wheat are the major crops of the district followed by sugarcane. In the district 99% of the area is irrigated by groundwater and only 0.34% is irrigated by canals, having a length of 800 km. As a result of the intensive year-round demand for groundwater, four out of the six blocks (Chamrawa, Shadnagar, Sahabad and Swar), have been classified as 'dark', a Government of India term representing a high level of over exploitation of the groundwater resources. Flooding is also a major problem in Rampur and surrounding areas. Other than the Ramganga, many of its tributaries e.g. Kosi, Pilakhar, Bhakra, can generate very high flows during the monsoon. Underground transfer of floods for irrigation (UTFI) is a novel approach for mitigating flood impacts through targeted floodwater storage in depleted aquifers for irrigating crops in the dry season. UTFI not only adopts the much-desired conjunctive use and management of water resources but also provides the environmental services that are of high socio-economic value. Pilot-scale demonstration and testing was done in Jiwai Jadid village of Milak block, Rampur district, Uttar Pradesh. In 2019 the total volume of water recharge from the entire system was determined to be 91825 m^3 or on average 1055.45 m^3/day over 87 days of recharge period. Results of the pilot testing shows that the retrofitted pond is effective in harvesting water, excess river flows and storing them underground for subsequent utilization and to offset falling trends. Suitability of UTFI under different categories were calculated. Most of the area (53%) is overlain by high UTFI suitability, followed by area under very high UTFI suitability (18.8%), and moderate UTFI suitability (12.4%). This shows the conditions in Rampur district are highly suitable for upscaling UTFI concept. Total 40 sites spread across 25 villages were visited and assessed for different attributes (such as current use, area, depth, connection with canal, distance from canal, quality of available water for recharge etc.) in Chamraua, Milak, Saidnagar and Swar blocks of district. After scrutinizing all the 40 sites for physical suitability different types recharge interventions were recommended. Total 8 number of ponds for recharge pit, 9 number of for recharge trench with wells, 6 number of ponds for vadose zone well and 17 number of ponds for percolation tank were suggested. Putting UTFI into practice across district requires its convergence into ongoing government programmes that are focused on livelihood improvement and natural resources management like Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA), Prime Minister Krishi Sinchayee Yojana (PMKSY), Rashtriya Krishi Vikas Yojana (RKVY),

Atal Bhujal Yojana (ABHY) and State Ground Water Conservation Mission (SGWCM). Based on availability of budget for district UTFI convergence matrix was recommended.

Key words: *UTFI Flood, Site suitability, Groundwater recharge and Government schemes*

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STUDIES ON VARIABILITY PARAMETERS IN EARLY SEGREGATING GENERATION FOR YIELD AND ITS COMPONENTS IN SOYBEAN (*Glycine max* (L.) Merril)

Meenakshi Bisht[1] and Kamendra Singh[2]

[1] Department of Agriculture, Integral Institute of Agricultural Science and Technology, Integral University, Lucknow, U.P. [2] Department of Genetics & Plant Breeding, College of Agriculture, GBPUAT, Pantnagar, Uttarakhand

Soybean (*Glycine max* (L.) Merril) is the world's most important and one of the oldest seed legume, which is also considered as miracle and premier oilseed crop with its 40 per cent protein and 20 per cent oil. The effectiveness of selection in any crops isdependent upon the nature, extent and magnitude of genetic variability present in material and extent to which it is heritable. Furthermore, heritability of a plant trait is very important in determining the response to selection because it implies the extent of transmissibility of traits into next generations.In addition, high genetic advance coupled with high heritability estimate offers the most effective condition for selection for a particular trait. Owing to the objective of the study, thirtysix genotypes of soybean with twelve quantitative characters were analyzed for the variability parameters in Randomized Complete Block Design during *kharif* 2015-16. In the study, the genotypes exhibited wide range of variability among the twelve characters. Generally the magnitude of PCV was found to be higher than the value of GCV and ECV. High value of PCV along with GCV was exhibited by yield per plant, harvest index, number of pods per plant, basal pod height, basal node height and dry matter weight per plant indicates the minimal role of environment and maximum role of genetic factors in expression of these characters. High heritability coupled with high genetic advance (%) was observed in dry matter weight per plant, plant height, basal node height, basal pod height, number of nodes per plant, number of primary branches per plant, number of pods per plant, yield per plant and harvest index, indicating the preponderance of additive gene action involved in the expression of these characters which could be highly rewarding during selection.

Key words: *Soybean, heritability, variability, genetic advance, yield*

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GROUNDWATER POTENTIAL ASSESSMENT IN HARD ROCK TERRAIN AREAS USING REMOTE SENSING, GIS &VERTICAL ELECTRICAL RESISTIVITY TECHNIQUE

Aniket Khare[1*], V.J. Ganvir[2] and Pushpesh Kumar[3]

[1]Student, Remote Sensing Applications Centre, Lucknow UP, [2]Scientist- SE& Head GWRD, Remote Sensing Applications Centre, Lucknow UP, [3]Project Scientist, Remote Sensing Applications Centre, Lucknow (UP)

**Corresponding author email: akkhare38@gmail.com*

Ground water is one of the major resources that contribute to the growth of any nation. However groundwater is getting depleted because of the population growth, unscientific irrigation practices, rapid urbanization and industrialization, etc. This increases demand of water for agriculture, household and industry. We have selected Mahrauni block of Lalitpur district, Uttar Pradesh for this study because it is

a hard rock terrain area. More than 90% of the population is dependent upon agriculture in this region. As most of the surface water in this region dry up in summer season, ground water resources need to be developed. Survey of India toposheets and LISS III satellite imagery along with other data have been utilized to prepare various thematic layers *viz*. drainage density, slope, lineament, hydrogeomorphology. With the help of VES technique overburden thickness map, aquifer thickness map and depth to basement map are prepared. Schlumberger setup is used to study physical properties and also to identify vertical and horizontal variations of sub surface features on earth. All the thematic map that influence ground water occurrences have been analyzed and integrated through ArcGIS. The weighted index overlay method has been followed to delineate ground water potential zones. The result shows that the study area can be categorized into different ground water potential zones viz., excellent, good, moderate and poor zones. The validity of the map prepared was checked against the bore well yield data, which reflects the actual groundwater potential. Thus, the above study has clearly demonstrated the capabilities of Remote sensing, geophysics and GIS technique in demarcation of the different groundwater potential zones.

Key words: *Remote sensing, Hard rock terrain, Groundwater potential zones, VES technique, Schlumberger setup, ArcGIS, Weighted index overlay*

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ASSESSMENT OF DIFFERENT LEVELS OF MICRONUTRIENTS ON CROP GROWTH AND YIELD PARAMETERS OF GREEN GRAM (*Vigna radiate* L.)

Aravind Gidaganti, Mohd. Noman*, Iska Srinath Reddy, Kapil Kumar Yadav and Arun Alfred David

Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj-211007, U.P., India

**Corresponding author Email: mohdnomanoct1997@gmail.com*

A field study was conducted on the "Effect of different levels of Micronutrients on crop growth and yield parameters of Green gram [*Vigna radiata* L.] Cv. IPM 02-03, at the Soil Science Research Farm, Sam HIgginbottom University of Agriculture, Technology and Sciences, Prayagraj during Kharif season 2018. The soil of experimnetal area falls in order Inceptisol and soil texture was sandy loam.The result showed plant height 52.9cm at 45 DAS, number of leaves plant^{-1} 18.0 at 45 DAS, number of pods plant^{-1} 21.3 at 60 DAS, Test weight 36.6g, Seed yield 32.37q ha^{-1} were significantly increased with the application of recommended dose of NPK fertilizers and 100% $ZnSO_4$ and 100% $FeSO_4$ fertilizers. The Maximum no. of seeds per pod (9.16) at 60 DAS was obtained in T_6 – [RDF + Zn@25 Kg ha^{-1} + Fe@10Kg ha^{-1}]. Growth parameters yield parameters increased significantly in T_8 and T_6 treatments. Bulk density, Particle density and Pore space % decreased with the increased application of fertilizers. The pH and EC of the post harvest soil decreased with the increased levels of fertilizers where the highest values were obtain in control plots. The organic carbon % found to be increased with fertilizer levels 0.76 in T_8. The NPK, Zn and Fe content in the soil increased with levels of fertilizers in treatment T_8 (RDF + Zn 100% + Fe 100%). The lowest values related to NPK, Zn and Fe parameters were obtained in control plot treatment. The lowest values related to all parameters were obtained in control plot treatment. Benefit cost ratio (B : C) 1:4 was highest in T_6 – (i.e. RDF + Zn@100% + Fe@50%) was more profitable 135020.00 Rs ha^{-1} than any other treatments and recommendations.

Key words: *Micronutrients, Benefit cost ratio, Green gram, Test weight*

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PRECISION WATER MANAGEMENT FOR IMPROVING WATER PRODUCTIVITY

Rakesh Kumar[1]*, Joginder Kumar[2], Anupama Rawat[3], Anita Arya[4] and Prayasi Nayak[5]

[1,3,4,5]Ph.D. Research Scholar, Department of Agronomy, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand-263145

[2]Department of Soil Science and Agricultural Chemistry

**Corresponding author email: rakeshsarswat58@gmail.com*

In many countries, water scarcity represents a critical constraint to food production and a major cause of poverty and hunger. Improved water management holds the key to producing enough food to alleviate the suffering of today and feed an additional millions of people by the year 2050. Much of this water is wasted, as much as 60 percent of the water withdrawn for irrigation often does not reach the crop use. It is lost through canal leakage, spillage, percolation and unproductive evaporation, although some of this water reaches to the river or groundwater. In addition to better water-use efficiency and potential to help conserve this important resource precision irrigation helps growers to manage the other precious resources more effectively, produce healthier crops, higher productivity, and make a difference in nutrient content. Variable rate irrigation (VRI) systems can be integrated into most irrigation systems including micro-sprinklers, drip, and overhead sprinklers by incorporating the right controllers and software. Drip irrigation is among the most exciting developments in irrigation technology. Drip irrigation is capable of what many would consider "precision irrigation" or "variable rate irrigation" by the use of pumps and valves that can be manually or automatically controlled, even down to the individual plant level. This level of control can dramatically increase irrigation efficiency and provide substantial water savings.VRI can allow a producer to address this variability and efficiently conserve resources and improve production. Global Position Systems (GPS) have become ubiquitous today, and this accessibility has enabled precision agriculture and is now finding its way into irrigation. In the field, geolocation of managing zones, utilization of VRI, and understanding data from soil moisture probes all rely on GPS technology. Monitoring and Automation systems not only allow growers to monitor soil and weather conditions, but can also allow them to remotely control irrigation systems, such as turning pumps, center pivots, and other systems on and off. Water management will likely become an increasingly important topic in agriculture as we try to meet the needs of a growing global population and compete for the water needed to grow our food. Irrigation and water management has lagged behind other areas in terms of technological developments, but is now joining the 21st century with technologies such as variable rate, monitoring systems, and more efficient methods of delivery, the future is green.

Key words: *Precision water management, Water Productivity, Variable rate irrigation, Productivity*

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NON-TIMBER FOREST PRODUCTS (NTFPS) AND LIVELIHOOD SECURITY: CHALLENGES AND STRATEGIES

Gyanaranjan Sahoo*and Afaq Majid Wani[1]

**Krishi Vigyan Kendra, Odisha University of Agriculture & Technology, Angul, Odisha 759132, India.*
[1]Dept of Forest Biology & Tree Improvement, College of Forestry, Sam Higginbottom University of Agriculture Technology and Sciences, Uttar Pradesh 211007 India.
**Corresponding author email: gyanaranjan.sahoo3@gmail.com*

Non-timber woods items have been a fundamental hotspot for food, medication, and handiwork items among the native populaces living in forested territories forcenturies. Logical exploration on the rebuilding of the significance of NTFPs and their worth expansion might actually direct the advancement of new nutraceutical items later on. Non-wood forest products market potential to accomplish vocation improvement andneediness decrease goals is regularly compelled by financial variables. There is a developing comprehension about NTFPs yet its significance has not been completely presented inside government structures and provincial advancement arrangements and projects. Non-wood forest items establish a significant wellspring of occupation for a great many individuals from forest periphery networks across the world. In India, NTFPs are relatedwith financial and social existence of timberland subordinate networks possessing in wide environmental and geo-climatic conditions all through the country. It is assessed that 275million poor rural individuals in India, rely upon NTFPs for in any event part of their means and money occupations. The NTFPs additionally fill in as an indispensable job security net inthe midst of difficulty. Moreover, the NTFP extraction has multiplier impacts in the economy by producing business and pay in downstream handling and exchanging exercises. In anycase, consumption of NTFPs assets because of unpredictable abuse, deforestation andwoodland debasement have a significant issue of worry that may influence the NTFP basedlivelihood and financial aspects.

Key words: *Climate change, Non wood forest products, Rural development, Forest sustainability, Strategies*

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EFFECT OF ROCK PHOSPHATE IN COMBINATION WITH SINGLE SUPER PHOSPHATE ON YIELD, P UPTAKE AND EFFICIENCY UNDER MAIZE-GROUNDNUT CROPPING SEQUENCE IN *ALFISOL* OF ODISHA

Samanyita Mohanty and G.H. Santra

[1]Department of Soil Science and Agricultural Chemistry, Odisha University of Agriculture and Technology, Bhubaneswar, 751003, Odisha

A field experiment was conducted during 2016-17 in *Alfisols* of Odisha to monitor the effects of different sources of phosphorus and its combination on productivity and nutrient uptake by maize-groundnut cropping sequence. Low Grade Rock phosphate (RP) and its various combinations with SSP were used as nutrient sources during *Kharif* 2016 (maize crop) and *Rabi* 2016-17 (groundnut crop). The study comprised of eight treatments; T_1 Control, T_2 100% P(RP),T_3 100% P(SSP), T_4 75% P(RP) + 25% P(SSP), T_5 50% P(RP) + 50% P(SSP), T_6 25% P(RP) + 75% P(SSP), T_7 200%P(RP) (only on first crop) and T_8 100% P(SSP) + Lime @ 0.2 LR and were replicated thrice and they were evaluated for their effectiveness in the cropping system. Better performance of rock phosphate in combination with SSP at various proportions was observed as compared to lone rock phosphate or SSP sources. The combination

significantly influenced the yield and phosphorus uptake of both maize and groundnut crops. Among the combination, equal proportion mixture of soluble (SSP) and insoluble (RP) source of P outreached the other combination ratios in terms of phosphorus use efficiency (PUE) and apparent phosphorus recovery (APR). The performance of the treatment which received lime along with water soluble P source proved to be best under acidic soil condition.

Key words: *Rock phosphate, Single super phosphate, Acid soils, Phosphorus use efficiency, Apparent phosphorus recovery*

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INTEGRATED FARMING SYSTEM APPROACH FOR INCOME ENHANCEMENT OF MARGINAL AND SMALL FARMERS

Anita Arya* and Rakesh Sarswat

Department of Agronomy, G. B. Pant University of Agriculture & Technology, Pantnagar - 263145. U. S. Nagar, Uttarakhand, India

**Corresponding author email: anitaarya95@gmail.com*

The average holding of a farm in India has been declining and cover 80 out of 105 million operational holdings are now below the size of 1.00 ha. Conventional farming is risky and farmers are reluctant to invest heavily in crop production. With increasing pressure from the burgeoning human population, only vertical expansion is possible by integrating appropriate farming components requiring lesser space and time and ensuring periodic income to the farmer. The integrated farming system therefore, assumes greater importance for the sound management of farm resources to enhance the farm productivity, reduce the environmental degradation, improve quality of life for resource poor farmers and to maintain sustainability. Integrated Farming System (IFS) is considered as one of the best option towards intensification of small holder farm income to ensure sustainable livelihood. Integration of resources is made through a combination of land, water and animal resources of a farm through careful planning including recycling of bio-resources. Integrated Farming System (IFS) plays an important role for maximizing their profit and production to meet the nutritional requirement with food security with less investment. Further in IFS it is more advantageous that the farmers are able to produce more by using optimal resource utilization and recycling of waste materials and family labour employment. Therefore farming system approach have the potential to integrate different combinations of enterprises and to study their interaction effect with resources available to the farmers and the environment without dislocating the ecological and socio-economic balance on one hand and attempts to meet the national goals on the other.

Key words: *IFS, Socio-eonomic, Food security*

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RESPONSE OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL PROPERTIES AND IRRIGATION WATER QUALITY

Sanjay Kumar Dangi, Iska Srinath Reddy*, Srinidhi P., Satya Ranjan Mohanta and Arun Alfred David

Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj- 211 007, UP, India

**Corresponding author email: iskasrinathreddy@gmail.com*

Study of physico-chemical properties of irrigation water quality and micro nutrients status at various soil depths (cm) of soil was conducted at different departments of Sam Higginbottom University of Agriculture Technology and Sciences in 2018-19. The main objectives of this study is to collect information of soil type and various parameters like pH, conductivity, bulk density, water retaining capacity, moisture content, available nitrogen, available phosphorous, available potassium. Five sampling points were selected from different departments (SHUATS). Soil was found to be slightly acidic. The nitrogen, phosphorous, potassium values are found to be low in all departments. Total hardness $CaCO_3$ (meq L^{-1}), turbidity (NTU), temperature (^0C), EC (dS m^{-1}), totally dissolved solids (mg L^{-1}), dissolved oxygen (mg $L^{-1)}$, alkalinity (mg L^{-1}), chloride (mg L^{-1}) and micro nutrient Mn, Ni, Pb, Cu. The electrical conductivity ranged from 0.13 to 1.23 dS m^{-1}. The pH value ranged from 7.65 to 8.17, the total dissolved solids ranged from 180 to 587 mg $L^{-1.}$ The dissolved oxygen ranged from 1.00 to 3.4 mg $L^{-1.}$ The biochemical oxygen demand value ranged from 99.02 to 145.09 mg $L^{-1.}$ The chemical oxygen demand value ranged from 198 to 248.08 mg $L^{-1.}$ The chloride content ranged from 80 to 295 mg L^{-1}. The total manganese content was not detected. The total copper content ranged from 0.98 to 2.40 ppm. The total copper content varied from 0.03 to 0.06ppm.

Key words: *Chemical and physical properties, Irrigation water quality, Micro nutrient*

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CROP RESIDUE DECOMPOSITION THROUGH POTENTIAL MICROBES TO COMBAT RESIDUE BURNING

Sanjay Arora, Y.P. Singh, A.K. Singh and Roopam*

ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow (U.P.)

**Corresponding author email: roops93.13@gmail.com*

Crop residues, especially in the irrigated agriculture, are typically burnt on-farm across different states of the country. The most common practice adopted by farmers is burning, especially in areas where the succeeding crop is grown in a short time thus allowing less time for its incorporation into soil for decomposition. Burning is implicated for causing pollution and affecting soil fertility adversely. Alternative to burning, rice straw management options remain costlier either for its incorporation into the soil or its conversion to compost. To clear 500 (approx.) million tonnes of residue from the field rapidly, farmers opt for easy and inexpensive solution i.e. in-situ burning. About 90% of 17 million tonnes of paddy straw produced burnt every year in open fields of some states. This results in extensive impacts causing losses in soil nutrients, soil organic matter, production and productivity, air quality, biodiversity, and water and energy efficiency and on human and animal health. It is estimated that burning of straw results in N, P, K, S lost in the atmosphere emitting air pollutants (CO, NH_3, SO_2, NOX,

NMHC, volatile organic compounds), particulate matter (CFCs, polychlorinated dibenzo-p-dioxins, polycyclic aromatic hydrocarbons (PAH's) and polychlorinated dibenzofurans (PCDFs), greenhouse gases (CO_2, N_2O, CH_4) on a large scale that majorly contributes to severe air pollution. Alternatives of burning such as bio-thermal power plants, for bedding material for animals, mushroom cultivation and biochar production are cost ineffective along with the demand of more labour and electricity. On the other hand, microbial approach for decomposition of crop residues developed as a low-cost technology. Microbes such as bacteria and fungi capable to naturally degrade and recycle the elements basically constitute the foundation of ecosystem. Straw mainly composed of cellulose, hemicellulose and lignin. Among these three components, lignin is the majorly complex amorphous heteropolymer with a three-dimensional structure composed of non-water soluble, optically inactive phenylpropane derivatives linked to each other by irregular coupling of C-C and C-O bonds. Lignin forms a physical impenetrable barrier in the plant cell wall linking to both hemicellulose and cellulose. Microorganisms such as fungi, bacteria and actinomycetes have the natural ability to grow on organic matter and decompose it through oxidative and enzymatic process which degrade lignin and open phenyl rings. A number of microorganisms are known to decompose lignin, cellulose and hemicellulosic structure. Fungi produces the extracellular enzymes lignin peroxidase (Lip) and manganese-dependent peroxidase (MnP) and laccase to degrade lignin; â-endoglucanase, â-glucosidase to break down cellulose; xylanase and mannase to decompose hemicellulosic structure. The best characterised degraders are white-rot basidiomycetes which are capable to degrade lignin upto 85%. Microbial approach also an efficient, eco-friendly and cheap alternative for the disruption of the lignocellulosic complex matrix. Studies evidently shows that the advantage of using consortia over of a single strain that have clear limitations with respect to versatility, because microbes such as fungi, bacteria and actinomycetes vary in their potential to delignify various types of plant cell walls. It has been proved that the microbial approach is best solution combating the problem of crop residues burning in addition, to some extent contributing in enhancing the soil fertility and nutrient availability. Thus, the characterization, identification and on-farm application of the most potential lignocellulolytic degrading microbes can degrade the residues in bulk in less possible time and replace burning practice.

Key words: *Paddy, Residue, Fungi, Decomposition*

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WEED MANAGEMENT OPTIONS IN CONSERVATION AGRICULTURE

Anurag Kumar Singh[1]*, Vivek Kumar[2] and Brijesh Kumar Chaudhary[1]

[1]Department of Agronomy, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005, [2]Department of Plant Physiology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005

**Corresponding author email: anuragk.singh3@bhu.ac.in*

Weed is a noxious plant which checks the growth of main cultivated crop. The composition of weed species mainly depends upon the type of agro ecological condition. The weed species found in rain-fed agriculture differs from irrigated situation. Similarly, annual crops such as wheat will have different weed species than the perennial cropping system. No tillage or low intensity tillage along with conservation agriculture weed flora are the major biological problems towards the large scale implementation of it, and are also considered to be one of the most important aspects in crop production under resource conservation agriculture as it does not allow the traditional means of weed management practices by ploughing and other intercultural operations to prepare the field for sowing. Resource conservation technologies are essential for preserving agricultural fertility and also meet future food demand either domestic population or global. In this context adequate weed control practices is important to make

these systems successful. Use of herbicide has been a precious advantage when adopting conservation agriculture practices. However, sensible use of chemical weed management is essential to fulfill the target of conservation agriculture through having reducing harmful environmental impact as well as reducing herbicide resistance development in weed flora. Increasing the crop density, retention of crop residue, band placement of fertilizer, breeding of competitive cultivars having allelopathic effect, crop rotation, stale seed bed technique, laser land leveling, adjustment of crop planting, biological weed control can be adopted for weed management. Herbicides which are considered to be an essential component of weed management in conservation agriculture can be used in conjunction with other options. Herbicide mixture, rotation of molecules, use of broad leaves and narrow leaves weeds targeting herbicide having interchange mode of action or integration of weed management practices is preferable. Since no single method of weed control can provide desired level of weed control, there is a need for integrating different weed management strategies like chemical, biological, physical for widening the weed control spectrum and efficiency under conservation agriculture.

Key words: *Conservation agriculture, Agricultural fertility, Agro ecological condition*

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RESOURCE CONSERVATION PRACTICES UNDERORGANIC FARMING IN RAINFED CONDITIONS OF WESTERN HIMALAYAN REGION OF INDIA

S. K. Yadav*, D.K. Singh, Shilpi Gupta, Kirti Sharma and Yogesh Sharma

Department of Agronomy, College of Agriculture, G.B.P.U.A.&T., Pantnagar, U.S. Nagar, Uttarakhand-263145, India
**Corresponding author email: santosh.yadav87@gmail.com*

Agricultural production is now facing the major challenges of high cost of production and degradation of natural resources which can be efficiently managed by adoption of resource conservation technologies under organic agriculture, but data on such resource conservation techniques are meagre. The present study was undertaken for five years (2013-14 to 2017-18) to identify efficient resource conservation options in organic agriculture under rainfed conditions of western Himalayan region of India. Eight treatments consisting of different resource conservation practices *viz.*, basmati rice-wheat-*Sesbania* (green manure) system (T_1); system of rice intensification (SRI) rice raising technique-wheat-*Sesbania* (T_2); direct seeded rice (DSR)- wheat(zero tillage)-*Sesbania* system (T_3); DSR-wheat-moong on broad bed and furrow system (T_4); DSR- vegetable pea- cowpea on broad bed and furrow system (T_5); DSR- chickpea –moong on broad bed and furrow system (T_6); DSR + soybean on furrow in raised bed system-vegetable pea + mustard (T_7) and Rice + pigeon pea- cow pea + okra mustard on furrow in raised bed system (T_8) were accommodated in a randomized block design with 3 replications during *kharif* (rainy) and *Rabi* (winter) seasons. As the main challenge for the organic production is farm based input production and disease management, treatment DSR- chickpea –moong on broad bed and furrow system (T_6), DSR- vegetable pea- cowpea on broad bed and furrow system (T_5)and DSR + soybean -vegetable pea + mustard on furrow in raised bed system (T_7), showed promising results to increase farmer's profitability with increased system productivity of basmati rice based bio-intensive cropping systems with small or marginal land holdings under organic production system.

Key words: *Organic Agriculture, Direct seeded rice, Broad bed and furrow system, Furrow in raised bed system, Sesbania green manuring, SRI, Zero tillage*

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ISOLATION AND CHARACTERIZATION OF BACTERIAL ISOLATES AS CROP RESIDUE DECOMPOSER ISOLATED FROM DIFFERENT SOURCES

Poonam Yadav[1,2*], MalaTrivedi[1] and S. R. Singh[2]

[1]Amity Institute of Biotechnology, Amity University Uttar Pradesh, Lucknow Campus 226025 [2]Indian Institute of Sugarcane Research, Lucknow-226002

**Corresponding author email: poonamyadav131@gmail.com*

Crop residues are materials left on cultivated land after the crop has been harvested. Retention of crop residues after harvesting is considered to be an effective anti-erosion measure. Crop residues can improve soil structure, increase organic matter content in the soil, reduce evaporation, and help fix CO_2 in the soil. Good residue management practices on agricultural lands have many positive impacts on soil quality. Besides, crop residues can be used in biofuel production. Information on residue cover guides policies for promoting beneficial management practices and helps to estimate soil carbon. We isolated eighty cellulose degrading bacteria from the guts of cellulose feeding organisms viz., cow dung, earthworms, termite, snail and rumens of animals residues collected from slaughter house. In which, thirty isolates were screened out as promising isolates of cellulose degrading bacteria and identified as crop residue decomposing ability of bacteria on the basis of biochemical analysis *in-vitro*. The bacterial isolates viz., CRD1, CRD10 and CRD29 recorded highest cellulase production activity whereas CRD5, CRD8, CRD4, CRD19, CRD20 and CRD21 recorded highest pectinase activity. The ß-glucosidase production was highest in CRD10, CRD3, CRD13, CRD15 followed by CRD14 but chitinase production showed highest in CRD6, CRD26, CRD25, CRD17, CRD15, CRD29 followed by CRD18. Out of 30 promising isolates of crop residue decomposing bacteria CRD3 showed highest activity followed by CRD10, CRD28, CRD12, CRD15, CRD26, CRD20 and CRD29. The isolates viz., CRD10, CRD12,CRD19 and CRD26 showed highest catalase activity whereas H_2S production was recorded highest in CRD5, CRD6, CRD20, CRD21, CRD25 and CRD26 isolates. Casein hydrolysis was observed highest in CRD1, CRD6, CRD8, CRD13, CRD16, CRD17, CRD24, and CRD25. The highest ammonia production was recorded with CRD4, CRD8, CRD12, CRD14, CRD15, CRD17, CRD21 and CRD24.

Key words: *Bacterial isolates, Residue management, Cellulase*

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FUNGAL COMMUNITY DIVERSITY IN BIODYNAMIC PREPARATIONS

Supriya Vaish[1*], Neelima Garg[1] and Iffat Zareen Ahmad[2]

[1]Division of Post HarvestManagment, ICAR-CISH, Lucknow[2], Department of Bioengineering, Integral University, Lucknow

**Corresponding author email: supriyavaish16@gmail.com*

Biodynamic (BD) farming is the one of the oldest organized agriculture farming system which claims to maintain sustainable soil fertility and build relationship between plant growth and yield. This farming system involves the use of eight biodynamic preparations (BD 500-BD 507). It is well proven that multi functionality of any ecosystem is due to its microbial diversity and community composition. The role of fungi in any ecosystem is important in decomposition of organic matter, nutrient availability to plants as well as activity of biological agents against pathogens. In the present study, ITS based metagenomic analysis was done to identify and establish the fungal diversity existing in these preparations at phylum,

genus and species level. Alpha diversity was found to be maximum in BD506 with 868 OTU (operational taxanomic units) and minimum in BD507 with 254 OTU. At phylum level, the most abundant phylum in 7 BD preparations was found to be Ascomycota except in the preparation BD 500. At genus level highest percentage of OTU abundance was observed for Mortierella in BD 500 and BD 502; Microascus in BD 501 and BD504; Gymnoascus in BD503, Scedosporium in BD 505, Mucor in BD 506 and Hyphopichia in BD 507. On the basis of species diversity, BD502, 503 and 506 showed high percentage of OTU abundance for *Mucorracemosus* species, while in BD500 for *Mortierella oligospora*, BD 501 for *Dipodascus geotrichum*, BD504 for *Kerniapachypleura*, BD505 for *Petriellasetifera* and BD 507 for *Hyphopichia burtonii*. The study also revealed presence of a large proportion belonging to unassigned fungi at phylum and genus level, which could be responsible for effectiveness of BD preparations under field conditions.

Key words: *Biodynamic preparations, Metagenomic, Operational taxonomic units (I), Fungal diversity*

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IMPROVED WATER PRODUCTIVITY OF WHEAT CROP IN THE COMMAND AREA OF MINOR IRRIGATION PROJECT

Mahesh Prasad Tripathi[1], Sandeep Kumar Pandey*, Pramod Kumar Mishra and S. K. Pandey

[1]Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib (H.P),
College of Agriculture Kotwa, Azamgarh, ANDUA&T Kumarganj,Ayodhya (U.P)
**Corresponding author email: sandeeppandeynduat@gmail.com*

The present study was taken up to promote importance of irrigation management and the water users' participation in increasing water productivity and the development of the existing irrigation in command area. This study was carried out to assess the present irrigation system of command area and to perform diagnostic study for the possible improvement in the command area of Khapa and Magardha minor. The experiment was conducted in Randomized block designs replicated three times; the experiment consists of three irrigation methods (Flood, Border and Sprinkler) two wheat varieties (GW-272 and HD-2851) and two method of sowing (broadcasting and line sowing). During study water productivity, depth of irrigation and crop yield were worked out. The study considered various canals and financial indicator to check the current status of economic utilization visibility of existing minor irrigation project. The results of study/work done during last two years indicated that the resource utilization in current perspective was not fully utilized and efficient planning need to be done to increase the productivity as well as farm income. The minor irrigation project located in the Mandla district of Madhya Pradesh (India). To improve the productivity of the wheat crop in command area, the adaptive research trials were conducted in a farmer's field, eighteen trials in each command Khapa and Magardha, respectively.

Key words: *Border irrigation, Flood irrigation, Sprinkler irrigation, Water productivity*

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EFFECT OF IRRIGATION MANAGEMENT ON YIELD AND QUALITY OF WHEAT (*Triticum aestivum* L.)

Ram Niwas[1], B.N. Singh[2], V.K. Verma[3], Ram Pyare [4], Dhananjai Singh[5], Kishan Kumar[6] and Vishesh Kumar[7]

[1&6]Ph.D. Scholar, Department of Agronomy, CSAUA&T, Kanpur, Uttar Pradesh, [2]Assistant Professor, Department of Agronomy, ANDUA&T, Kumarganj, Ayodhya, Uttar Pradesh,[3&5]Associate Professor, Department of Agronomy, CSAUA&T, Kanpur, Uttar Pradesh,[7]Ph.D. Scholar, Department of Agrometeorology, GBPUA&T, Pantnagar, Uttarakhand, [4]Professor, Department of Agronomy, CSAUA&T, Kanpur, Uttar Pradesh, India

**Corresponding author Email: ramniwas9161@gmail.com, videshkumarverma@gmail.com*

An experiment was conducted during *rabi* season of 2017-18 at Agronomy Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, situated at 26.47^0 North latitude, 80.120^0 East longitude at an altitude of about 113.0 meter from mean sea level. Irrigation management on the basis of soil moisture regimes and critical growth stages was used as strategy in this quest to harness water use efficiency, water productivity and yield of wheat crop. The experiment comprised of eight (8) treatments of moisture regimes viz. (i) 0.8 IW/CPE ratio (ii) 1.0 IW/ CPE ratio (iii) 1.2 IW/CPE ratio (iv) two irrigations each at CRI & LJS (v) three irrigations each at CRI, LJS & MKS (vi) four irrigations each at CRI, TRS, LJS, & FRS (vii) five irrigations each at CRI, TRS, LJS, FRS & MKS (viii) six irrigations each at CRI, TRS, LJS, FRS, MKS & DS. The experiment was laid out in Randomized Block Design (RBD) with four replications. The wheat variety PBW-502 was used for sowing. The crop was fertilized with recommended dose of NPK and other cultural operations were performed accordingly. The result revealed that irrigations provided in the crop either at soil moisture regimes (IW/ CPE ratio) or at critical growth stages of crop did not recognize any significant difference. The treatment that provided six irrigations either at 1.0 IW/CPE ratio or at critical growth stages (CRI, TRS, LJS, FRS, MKS & DS) recorded maximum yield potential (45.40 to 46.00 qha^{-1} grain yield and 65.83 to 66.29 qha^{-1} straw yield), enhanced nutrient uptake (Nitrogen 72.68 $Kgha^{-1}$, Phosphorus 18.03 $kgha^{-1}$ and Potassium 16.97 $kgha^{-1}$) in grain of wheat. Five irrigations were applied at CRI, TRS, LJS, FRS & MKS recorded significantly at par.

Key words: *Critical growth stage, Irrigation management, Moisture regimes, Nutrient uptake, Wheat, Yield*

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CLIMATE CHANGE EFFECT ON THE KOSHI RIVER BASIN

Priyanka Rani*

Sam Higginbottom University of Agriculture, Technology and Science, Allahabad

**Corresponding author email: priyasinha1229@gmail.com*

The Koshi River is an important tributary of theGanges River, which passes through China, Nepal and India. India beholds importance as having high potential for hydropower and irrigation development. Koshi River is known as the ''sorrow of Bihar'' because of its long and recurring flood hazards. The changing climate and hydrological extreme events can have a negative impact on water resource development and can cause natural hazards. The mean temperature in the KRB is increasing in recent past for more than 100 years at a rate of 0.87 ^{0}C per hundred years, while annual precipitation is decreasing at a rate of 120.9 mm per hundred years at the same period and fluctuation range is gradually widened. The change rate of temperature ranges from 0.4 to 0.9 ^{0}C per hundred years in the whole KRB,

while the change rate of precipitation range from less than 90 mm to 305 mm per hundred years. The most significant temperature increasing area is located at southern part of the KRB, while precipitation decreasing most significantly in the north western part of the KRB. Many studies has been carried out in the past that quantified the fundamental and practical aspect of Koshi River and also analysing the shifting and narrowing of the river. The paper revisited the flooding problem in the koshi river basin in present and in future too through the analysis of flood hydrology, land cover, topographic, geomorphological and population parameter for flood risk index and cost effective solution for planning mitigation measures in flood prone areas.

Key words: *Koshi River, Climate change, flood*

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INTEGRATED FARMING SYSTEMS FOR DOUBLING FARMER'S INCOME

Ruchika Abha*, M. L. Meena, B. C. Shivran and Rupesh Kumar Mondal

Department of Horticulture, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, VidyaVihar, Raebareli Road, Lucknow-226025
**Corresponding author email: abharuchika16@gmail.com*

In India, the farmers maintain different enterprises for their complimentary and supplementary nature and to increase the farmer's income and also full fill the need of food for increasing population. Integrated farming systems is defined as unique and reasonably stable arrangement of farm enterprises that the household manages according to its physical, biological, economic and socio-cultural environment in accordance with the household goals, preferences and resources. An integrated farming system is a commonly and broadly used word to explain a more integrated approach to farming as compared to mono-culture approaches. To accomplish the doubling farmer's income might require novel strategies and some change in the policy stance. For doubling of the farmer's income few vital strategies need transformation in agriculture production combined with integrated farming system (IFS) approaches that involves crop cultivation, dairy, poultry, fishery, mushroom cultivation, agro-forestry, piggery, beekeeping, vegetable and fruit production, use of renewable energy source (i.e. Solar energy, Biogas) etc. It improves space utilization and provides diversified products. The concepts associated with integrated farming systems are practiced by numerous farmers throughout the world. It is part of the strategy to ensure sustainable use of the natural resources for the benefit of present and future generations. Integrated farming system components are known to control the weed and regarded as an important element of integrated pest management and thus minimize the use of weed killers as well as pesticides and thereby protect the environment. Integrated farming systems provide an opportunity to increase economic yield per unit area by virtue of intensification of crop and allied enterprises especially for small and marginal farmers. Due to interaction of enterprises, integrated farming systems provides flow of money round the year amongst the farming community. The overall objective is to evolve technically feasible and economically viable farming system models by integrating cropping with allied enterprises for irrigated, rained, hilly and coastal areas with a view to generate income and employment from the farm. Organic supplementation through effective utilization of by-products of linked component is done thus providing an opportunity to sustain the potentiality of production base for much longer periods. Crop by-product is utilized as fodder for animals, and animal by-product i.e. milk, and dung may be utilized for increasing income and soil fertility, respectively. The goals of Integrated Farming Systems are provides a steady and stable income rejuvenation/amelioration of the system's productivity and to achieve agro-ecological equilibrium through the reduction in the build-up of pests and diseases, through natural

cropping system management and the reduction in the use of chemicals (inorganic fertilizers and pesticides). Crop diversification includes lot of promises in alleviating the problem of low productivity, sustainability, soil health, low income etc. through fulfilling the basic needs and regulating farm income, with standing weather aberrations, controlling price fluctuation, ensuring balance food supply, conserving natural resources, reducing the chemical fertilizer and pesticide loads, environmental safety and creating employment opportunity. It needs to transformation to provide divers set of services that support diversification with high value crops, agricultural livelihoods and offering relevant technologies that are integrated with appropriate credit support smart farming as well as policies implementation with MSP reform. In conclusion, the low and highly fluctuating agricultural productivity of major crops has been increased with implies that the current and previously achieved growth rate has to be sharply accelerated. It can be concluded that adoption of farming system approaches combined with allied innovative approaches plays an important vital role to meet the present day's challenges in agriculture.

Key words: *Crop diversification, Soil health, Integrated Farming Systems*

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METAGENOMIC ANALYSIS OF IMIDACLOPRID TREATED MANGO ORCHARD SOIL

Neelima Garg, A. K. Bhattacherjee and Pradeep Kr. Shukla

Division of Post Harvest Management, ICAR-Central Institute for Subtropical Horticulture, Lucknow, India

Malihabad region of Uttar Pradesh is known as mango belt. A major agro practice of this area is frequent application of pesticides to control various insect-pests and diseases. Imidacloprid is one such pesticide used to control mango hopper. Microbes play an important role in removing toxic pesticides from soil surface and microbial bioremediation is considered to be a cost effective tool for the detoxification of pesticides. Some bacteria like Bacillus, Enterobacter, Ochrobactrum, Pseudomonas, etc. have the potential to degrade various pesticides in soil. Sixteen microbes were isolated from imidacloprid treated soil. However, only 0.1 - 1 per cent of the microbes are culturable, while the rest are unculturable. With the advent of new generation sequencing technologies, metagenomics is an approach for understanding the diversity and related metabolic activities in any environmental sample without culturing the microbes. Metagenomic analysis of mango orchard soil was carried out to identify the difference in microbial population in imidacloprid applied soil and control soil. The DNA samples were quantified using Nanodrop and Qubit DNA BR Kit. Twenty five nanogram of DNA was used to amplify 16S rRNA hyper variable region V3-V4. Paired end data were given as input to QIIME and Operational taxonomy unit (OTU) were assigned to representative sequences. In control and imidacloprid applied soil samples, the number of representative sequences clustered were 0.142930 and 0.082320 million, respectively. At kingdom level 85 and 88% belonged to bacteria, 2 and 1% to Archea and 13 and 11% unassigned. At phylum level, 16% and 17% of OTUs were assigned with Proteobacteria in control and imidacloprid treated samples, whereas 13% and 11% of OTUs were unassigned in respective soil samples. The other phyla, which were abundant in both the samples, were Planctomycetes, Bacteroidetes and Actinobacteria. At class level, 9% and 11% of OTUs were assigned with Planctomycetia in control as well as imidacloprid treated samples, respectively. The number of OTUs present in control and imidacloprid applied samples are 31173 and 21909, respectively, with 18018 number of OTUs shared between the two samples. The analysis reveals that application of imidacloprid leads to changes in the soil microflora.

Key words: *Crop diversification, Soil health, Integrated Farming Systems*

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SOIL MOISTURE ESTIMATION OVER BARE AGRICULTURAL FIELDS OF CENTRAL STATE FARM HISAR USING MICROWAVE REMOTE SENSING

Anuradha Sharma*, Joydeep Mukherjee, V.K. Sehgal, D. Chakraborty and D.K. Das

Division of Agricultural Physics, ICAR-Indian Agricultural Research Institute, New Delhi 110012, India

**Corresponding author email: anuradhasharma264@gmail.com*

Surface soil moisture plays a key role in various agricultural applications. It is the controlling factor in exchanging the water and heat energy between the land surface and the atmosphere through evaporation and plant transpiration. Therefore it is vital component in weather and precipitation activity. The majorchallengein estimation of the soil moisture is that it varies from one point to another on the ground. Hence it is difficult to perform ground soil measurements over a large area due to limited time, cost and manpower resources. Active microwave remote sensing technology is the emerging technology that facilitates the measurement of soil moisture in a spatial domain at a cost efficient and in an effective manner. The microwave region of electromagnetic spectrum is considered as the optimum tool for monitoring the soil moisture due to the unique property of microwave sensitivity towards water contained i.e. the dielectric constant. There are various methods available to estimate the soil moisture such as backscatter models, change detection, interferometry approach. In this study,a semi empirical backscatter model i.e. Dubois model has been used to determine the soil moisture using freely available Sentinel-1C band data in VV polarization provided by the European Space Agency (ESA). The advantage of this model is that it provides a better way to implement over the area without requiring any other parameters. The input parameters such as ground soil moisture ($è_{mv}$) and surface roughness height (ó) have been collected on the bare agricultural fields of Central State Farm of Hisar and sensor parameters have been used in the parameterization of the model. Results of Dubois model derived soil moisture are validated with the ground collected soil moisture showed a good agreement with the R^2 value of 0.77.

Key words: *Soil moisture, Remote Sensing, Sentinel-1, Dubois model, Active microwave*

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RELEASE PATTERN OF BORON AS INFLUENCED BY APPLIED CALCIUM AND BORON IN DIFFERENT ACIDIC SOILS OF INCEPTISOL

Ajin S Anil, V.K. Sharma, Mandira Barman, S. P. Datta, Kapil A. Chobhe and K. K. Bandyopadhyay

Division of Soil Science and Agricultural Chemistry,
ICAR- Indian Agricultural Research Institute, New Delhi-110 012

Boron (B) deficiency is widespread in acid soils of India covering about 30% of the total cultivable area, affecting crop production gravely. Liming materials is commonly used to ameliorate the acid soil which raises the pH of soil, which in turn decreases the Al and Fe toxicity and also increases calcium (Ca) and magnesium (Mg) concentration in soils. Liming practices also increases B requirement of plant due to its similarity in function and reduces availability of B in soil due to the formation of Ca-metaborate complex. Also, it leads to significant changes in soil properties *viz.*, soil pH, oxides and hydroxides of Fe and Al and concentration of Ca in soil solution, these may influence the adsorption-desorption behaviour of B in soil and subsequently its availability to the crops. Therefore, release pattern of B in different acid

soils of Inceptisolas influenced by applied Ca and Bwas studied. For the study, the bulk acid surface soils of Inceptisol from three states *i.e.*Titabar (Assam), Thiruvanthapuram (Kerala) and Ratnagiri (Maharashtra) were collected. Incubation study was conducted under laboratory conditions using these different acid soils, where eight treatment combinations of Ca based on lime requirement (0, 1/3, 2/3 and 1.0 LR) and B (0 and 2 mg kg^{-1}) were added into soils. Salycilic acid extractable-B(SAE-B) was determined in treated soilsat 0, 15, 30 and 60 days after incubation. Results revealed that application of Ca reduced the SAE-Bin soils collected from Thiruvananthapuram and Ratnagiri.Salicylic acid extractable-B increased significantly and consistently with the application of B @ 2 mg kg^{-1} in all the acid soils collected from Assam, Kerala and Maharashtra. In all acid soils, SAE-B content was gradually decreased with the progression of incubation periods with significant differences.

Key words: *Acid soil, Boron, Calcium, Inceptisol*

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ASSESSMENT OF SOIL ORGANIC CARBON STATUS UNDER DIFFERENT LAND USE SYSTEMS IN BUNDELKHAND: A CASE STUDY OF MAHOBA DISTRICT, UTTAR PREDESH

Kaushlendra Singh, M.S. Yadav and Sanjeev Kumar

Remote Sensing Application Centre Uttar Pradesh, Lucknow-226021 (UP)

The assessment of present status of organic carbon in soils is an important study because it provides a state level soil organic carbon inventory for soil carbon sequestration and climate change studies. Additionally, agriculture practitioners can use these results to address land use change and to adopt appropriate land use management practices to enhance soil organic carbon capacity and fertility status of soils. This paper deals with the organic carbon status of different land use practices in Mahoba district of Bundelkhand region. IRS LISS-IV satellite images of 2017-18 have been used to delineate the different land use systems and as such, land use/land cover map of the district has been prepared. Ground truth information has also been incorporated to finalize the land use/ land cover classification. Grid base soil sampling has been undertaken for determination of soil organic carbon (SOC) and two sets of soil samples were randomly collected within the grid. Three major land use classes were indentified and delineated in Mahoba district viz, crop land, waste land and open forest. The waste land soil recorded high SOC followed by crop land and forest land in both top (0-20 cm) and bottom (020-50 cm) layers. The forest land having less SOC (0.30%) while the crop land and waste land also having 0.40% and 0.42%. SOC, respectively. The increased temperature, less rainfall in this region accentuates the oxidation of previously protected organic carbon in open forest land. Leaves of forest plants were hard and found undecomposed in lowers layers of soil. In case of waste land, which receive less disturbance through tillage activities having short herbs with soft leaves reduced the oxidation process and thus the litter accumulation on the surface, which is easily decomposed by microbial activity enhance the SOC in waste land, where as in crop land, which is disturbed through tillage practices having greater amount of SOC in comparison to open forest due to leguminous crop cover, However, the SOC in this region are far below the prescribed SOC status under different land use (0.52-0.7%). Selection of plant for open forest, incorporation of medicinal and aromatic plantation on wasteland and crop land, which is having less water requirement, is essential for enhancing the SOC levels in Mahoba district. The results from the laboratory were imported to Arc-GIS and Arc-info environment to generate the spatial variability map of SOC. These maps will furnish first hand information to authorities and advisers about the status of SOC in Mahoba district of the Bundelkhand region.

Key words: *Soil organic carbon, Forest plants, Mahoba district*

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USING INTEGRATED TECHNIQUES OF REMOTE SENSING AND GIS IN CHANGE DETECTION OF WETLAND IN THREE BLOCKS OF UNNAO DISTRICT

Paridhi Nagiyan*

Remote Sensing Applications Centre, UP, Lucknow
**Corresponding author email: paridhinagiyan@yahoo.com*

Water bodies attract man due to their ability to sustain and enrich life. India's wetland ecosystem forms a part of her rich natural heritage. The value of wetlands has only recently been recognized in regard to their ecological significance in terms of flood control, water purification, storm protection, aquatic productivity and micro climate regulation and as habitat of fish and wildlife conservation, education, scientific research etc. They are also used for irrigation purposes, water supply, and waste disposal. Wetland vegetation has long been regarded as a potential sink for many pollutants, associated with plants and sediments. Wetlands have important filtering capabilities for intercepting surface water runoff from higher dry land before the run off reaches open water.The study area covers change detection of wetlands within 8 years of three blocks of Unnao district of Uttar Pradesh. This task was accomplished using IRS-1C/ 1D LISS-3 post monsoon satellite images having 23.5m spatial resolution of Feb.1997 and Feb. 2005. The high resolution LISS-3 data has provided vital input in delineating land water boundary, boundaries of aquatic vegetation and level of turbidity. ERDAS IMAGINE 9.2 software was used for image rectification. ARC GIS software was used for data preparation, analysis and post analysis procedures. On screen digitization has been done for mapping of different types of wetlands of both years.The wetlands are categorized into 7 types i.e. natural pond/ lake oxbow lake/ cut off meander, natural water logging, river, manmade pond, manmade water logging, and canal. In Feb.1997 total area of wetland was found to be 26407788 m^2 and in Feb.2005 as 35527830.37m^2. The areal extent of wetlands in study area has been observed to increase in year 2005 in comparison to year 1997.The change in area of canal has not been observed.

Key words: *Resolution, GIS, Resolution, Wetland, Turbidity*

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ANALYSIS OF MORPHOMETRIC PARAMETERS OF MAND RIVER CATCHMENT IN CHHATISGARH USING GIS TECHNIQUE

Shreeya Baghel*, M.P. Tripathi, D. Khalkho and Aekesh Kumar

Dept. of Soil and Water Engineering, SVCAET & RS, IGKV, Raipur (C.G.)
**Corresponding author email: baghelshreeya1@gmail.com*

In countries like India, where the population is continuously increasing, land and water resources are limited and their wide utilization is imperative. Keeping in ever increasing population and need for food security, it is realized that the water and the land resources need to be developed, used and managed in an integrated and comprehensive manner. This can be achieved by adopting the systematic watershed management approach. Watershed is considered as a basic unit for overall development of a region. The advent of Geographic Information System techniques (GIS) allowed users for the quantitative characterization of landforms with higher speed and precision. The study area is Mand catchment of upper Mahanadi basin which is the part of Chhattisgarh having area of 5332 km^2, lies between

21°42’15.525"N to 23°4’19.746"N latitude and 82°50’54.503"E to 83°36’1.295"E longitude.Looking the importance of watershed management approach and capability of Arc-GIS and DEM, an attempt was made to determine morphometric parameters of a catchment. Digital Elevation Model (DEM) which is downloaded from USGS-SRTM is used for watershed delineation, extraction of stream networks and characterization of watershed topography by using watershed delineation tool of Arc-GIS. Different parameters of various aspects including 6 linear, 12 areal and 7 relief parameters of Mand catchment were found out in the environment of Arc-GIS. Standard methodology and formulae were applied as suggested by previous research workers in this study. Calculated values of main parameters are Basin length (155.474 km), Mean bifurcation ratio (6.606), Basin relief (960 m), Ruggedness number (0.405), Stream frequency (0.305), Drainage density (0.422 km/km^2) and Elongation ratio (0.530). The results of the morphometric analysis reveal that Mand catchment is more elongated with lower peak but extended peak flow. It has a strong relief and steep ground slope. The stream order of watershed ranges from first to fourth order showing dendritic type drainage. The catchment represents the steeply dipping rock strata. Based on results of this study, it can be concluded that remote sensing techniques coupled with GIS can be a powerful tool in morphometric analysis of a region or catchment.This study of morphometric analysis characterizes the catchment, helps to understand the hydrological behaviour and can be used for water resource management of the Mand catchment.

Key words: *DEM, Geographic Information System, Remote Sensing, Watershed Characteristics, Watershed Delineation*

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ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION IN KURUD BLOCK OF CHHATTISGARH

Aekesh Kumar*, M. P. Tripathi, D. Khalkho and Shreeya Baghel

Dept. of Soil and Water Engineering, SVCAET & RS, IGKV, Raipur (C.G.)
**Corresponding author email: aekesh008@gmail.com*

Groundwater resources play a major role in ensuring livelihood security across the world, especially in economies that depend on agriculture. Groundwater level is depleting fast in Chhattisgarh and there has been a significant increase chemical contamination in groundwater. An effort has been made to comprehend the groundwater suitability for irrigation purpose in Kurud block of Chhattisgarh using different methods. Where Kurud block fall in the semi-critical category with 78.34% groundwater development. In this study ten groundwater samples which represents entire block were collected during December, 2019. A standard method has been adopted in groundwater sampling which are prescribed by the American Public Health Association (APHA, 1995). Fourteen water quality parameters namely pH, EC, TDS, chloride, fluoride, calcium, magnesium, sodium, potassium, sulphate, total hardness, carbonate, bicarbonate and nitrate were analyzed at CGWB, NCCR Raipur. Suitability of groundwater for irrigation purpose generally based on Wilcox diagram, USSL Diagram, SAR, RSC, SSP, PI, %Na, TH and EC. With Wilcox diagram, 30% groundwater samples falls in excellent to good category, 70% samples are good to permissible-and 10% samples are permissible to doubt. The US Salinity Laboratory Staff plot depicted that all the groundwater sources are C2-S1 (Medium salinity-low sodium) and C3-S1 (High salinity-low sodium) type for the study area. The groundwater samples fall under C3-S1 can be used for irrigation especially for salt tolerance crops. Residual Sodium Carbonate has shown 60% samples are good, 30% samples are doubtful and only 10% samples are unsuitable for irrigation. On the basis of results of this studyit can be concluded that, the groundwater available in the study area was good for irrigation purpose, apart few samples which were exceeding the limits due to anthropogenic activities

and those samples were indisposed for irrigation. This dataset gives an idea about the groundwater quality indices of the studied block which helps the decision-makers to understand the status of the groundwater quality for irrigation purpose.

Key words: *Sodium absorption ration (SAR), Residual sodium carbonate (RSC), Soluble sodium percentage (SSP), Permeability index (PI), Percentage sodium (%Na)*

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WATER MANAGEMENT TECHNOLOGY FOR SUMMER FINGER MILLET IN MIDLAND SITUATION OF CHHATTISGARH PLAINS

M. P. Tripathi*, Karnika Dwivedi and Yatnesh Bisen

Dept. of Soil and Water Engg., SVCAET &RS, Faculty of Agriculture Engineering, IGKV, Raipur (CG)
**Corresponding author email: mktripathi64@gmail.com*

The present study deals with the effective water application practices at different Soil Moisture Depletion Level (SMDL) with combination of soil mulch to enhance water productivity of finger millet (ragi) during summer in mid land situation of Chhattisgarh plains. A field experiment on summer finger millet was carried out at research farm of Indira Gandhi KrishiVishwavidyalaya, Raipur during summer season in 2014, 2015 and 2016 to evaluate two main treatments of moisture conservation (soil mulch and without mulch) with combination of five sub main treatments i.e. 30% SMDL, 40% SMDL, 50% SMDL, 60% SMDL and 70% SMDL. A trial was also conducted on summer rice adjacent to this experiment to assess the techno economic comparison with summer finger millet. The results of this study showed that the grain yield of finger millet in combination of soil mulch with 60 % SMDL gave the significant higher yield of 23.48 q ha^{-1} under split plot design. The water use efficiency is also higher in combination of soil mulch with 60 % SMDL (6.21 kg $ha^{-1}mm^{-1}$) as compared to combination of soil mulch with 50 % SMDL (6.10 kg $ha^{-1}mm^{-1}$). On the basis of pooled data of three consecutive years, it can be concluded that the water requirement of summer ragi is 375 mm, which can be accomplished by eight numbers of irrigation. It can be concluded that 755 mm per hectare of water can be saved if finger millet (ragi) is grown in place of summer rice. The water saving can increase the cultivated area more than 3 times under summer finger millet as compared to summer rice. On the basis of this study, cultivation of summer finger millet is recommended in place of summer rice in Chhattisgarh plains.

Key words: *Finger millet, Irrigation, Soil moisture depletion level, Soil mulch, Summer rice, Water management, Water use efficiency*

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GPS: AN EVOLUTIONARY TOOL FOR THE FERTILIZER APPLICATION OF BANDA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY (BUAT) SOILS

Shivam Singh[1*], Jagannath Pathak [2], Mahendra Pratap Singh[3], A.K. Chaubey[4], J.K. Tiwari[5], Amit Mishra[6] and Saurabh Singh[7]

Department of Soil Science and Agricultural Chemistry, Banda University of Agriculture and Technology, Banda, 210001 (UP), [3] KVK (Tissuhi) Sonbhadra, Narendra Dev University of Agriculture and Technology, Kumarganj, Faizabad, 224229 (UP) India

**Corresponding author email: shivamsinghnscacademy@gmail.com*

An investigation was made in the year 2019-20 to assess the physico-chemical status of the soil in Banda University of Agriculture and Technology, Uttar Pradesh, India. Total 85 samples were collected as per sampling techniques to investigate four parameters namely pH, EC (dSm^{-1}), Eh and salt concentration (ppm) using pH Meter and EC Meter. The area of sampling included College of Agriculture, College of Horticulture and College of Forestry. 7.45% of the soil samples were found to be neutral in reaction whereas 72.53% were slightly saline in reaction and 6.38% slightly acidic. The similar constraints were found in Eh. However, EC and salt concentration (ppm) remained in the safe range (i.e., < $0.48dSm^{-1}$). The mean value of pH, EC, Eh and salt concentration (ppm) were 7.49, $0.08506\ dSm^{-1}$, 0.44285 and 1.36×10^6 ppm respectively. Thematic maps were prepared for each soil parameter using Google Earth Pro Software to provideready understanding information about the fertility status and serve as judicious decision makeup for successful production under the university premises.

Key words: *Physico-chemical status, pH, EC, Eh, Salt concentration*

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MUSHROOM AGRONOMY: AN OFFERING TO SOCIETY

Nishalika Singh* and Nisha Mourya*

Department of Life Science, Babasaheb Bhimrao Ambedkar University

**Corresponding author email: nishalikasinghrathore@gmail.com, nisha101m@gmail.com*

Due to traditional agriculture methods, farmer's income has been depleting year by year. To help farmers increase their source of income, there should be diversification in the source of income for which comes the term integrated farming. The integrated farming system in general terms involves the use of natural resources in a regulated mechanism into farming activities to achieve maximum replacement of off-farm inputs and sustain farm income. Mushrooms could easily be grown on straws and agricultural wastes and its cultivation is an indoor activity thus the production of mushroom could be a great source for a secondary income of farmers. The agronomy of mushroom is very beneficial due to minimal investment and hefty profit. The production of mushrooms along with various crops, fish culture, and poultry line with a good farm and resource availability can lead towards a better income for the farmers and environmental sustainability. Mushrooms are fungi so they act as decomposers and help in the conversion of waste materials into manure which can be used in the farms. Mushrooms contain low calories but are a rich source of fiber vitamins and minerals. Mushroom contains all nine essential amino acids with high digestibility, vitamin B2 and B3, folic acid, copper, selenium and are the only vegetarian source of vitamin D. Mushroom also have medicinal values as they help in developing better immune

system and they also have anti-cancer properties which reduce the side effects of radio and chemotherapy. Due to the high nutritional value of mushrooms, their increased production will help in eradicating malnutrition in children resulting in a healthy society. Mushrooms certainly fit into the modern functional foods category. It could be added to the ready-to-cook and ready-to-eat foods available. They can be an addition to traditional and fast food products providing an increased market for the consumption and production of mushrooms. Wide variety of mushrooms that could be effortlessly produced throughout the year with minimal land area and requirements helping in a reserved source of income throughout the year. The economy of various countries like China and Japan have a part of their economy based on mushroom production. India could also increase their economy by mushroom production thus the government has also started many government policies for motivating farmers to start mushroom production.

This study provides a piece of wide information about the oyster and button mushroom that could be produced in India, the setup of the room and the procedure to be followed for their production. This is to motivate people to get involved in the production of mushrooms and help in increasing the economy of the country and also the betterment of society.

Key words: *Farming, Cultivation, Income, Nutritional value, Security*

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WASTE WATER (SEWAGE-FED) AQUACULTURE

Alok Ranjan and Shreya Vidyarthi

Department of Zoology, Babasaheb Bhimrao Ambedkar University, Lucknow (UP)

Water have been rightly referred as resource out of place, since house hold waste water often intermixes with effluent from industry and agriculture runoff, multi-dimensional approaches have been made towards maximizing protein production through rational exploitation of available resources. Sewage fed aquaculture is a unique system that has unique advantage in developed tropical countries. It acts as major source of nutrient for aquaculture. A large number of people derived their livelihood from sewage fed aquaculture using the principle of system ecology and applying it through ecological engineering. A subject of sewage fed aquaculture is reviewed in terms of source, chemical nature, diversity pattern, cycling practices, production of potential for aquaculture. Generally major carps are mostly referred as source for aquaculture like Rohu, Catla, Mangur etc. That help the rural people to grade-up their poverty line. And also, it demands for growing fish industry of metro city that are industry for growing and conservation of natural resource and biodiversity. Advantage of sewage fed aquaculture is that its input cost is very low and production is very high. It is a biological method of treating the waste water before its final disposal in river. It reduces pollution load of river and aquatic ecosystem. It uses the waste recycling process and maintains the good environment around the urban areas.

Key words: *Effluent, Sewage, Aquaculture, Fish*

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MANAGEMENT OF SOIL AND WATER RESOURCES FOR SUSTAINABLE CROP PRODUCTION

Subham Mishra, Himanshu Shukla and Raghvendra Pratap Singh

Chandrabhan Gupta P.G. College, Lucknow (UP)

Conservation and management of soil and water resources improve soil health and crop productivity. Improved soil management may increase infiltration and reduces water runoff. Soil and water are under enormous pressure due to increasing population in that ensuring growing demand and need for food, roughage and shed. Soil and water are being degraded due to different contaminations and other natural factors. For sustainable crop production it is admissible to protect the soil resources against erosion. Water and wind are the major agencies which are responsible for soil erosion. Soil erosion leads to the significant loss of soil productivity and thus may lead to the desertification. Various control measures must be adopted to avoid soil erosion. Afforestation, mulching, contour forming, strip cropping, terracing, gully reclamation, shelter belt and conservation tillage prevents the soil erosion. Increasing sustainable crop production to meet the food requirement of growing population will put massive pressure on water resources. Soil and water are basic necessities for the agriculture. The efficient use of limited water resources will lead to the sustainable crop production. Water is one of the most vital resources for the survival of human being, animal and other microbes. Fresh water is a limited source only 1% of which is available for domestic usage and that too is not distributed equally. Some area has good availability of fresh water and some lack it. Food supply, human health, welfare and over all development are totally depend on land, water and other natural resources. Integrated water resource management is one such concept which essentially focuses on managing water resources. Ocean, river, ponds, rainfall and glaciers are the primary resources of water for irrigation and fulfill daily domestic as well as industrial usages. We must conserve our water resources and keep them pollution free. Various irrigation techniques are adopted by the farmers for the management of water for sustainable crop production. Bamboo drip irrigation, percolation tanks, check dams and desalination are urgently required for the conservation of water. Leak management is much needed in households as more than 45% of water go waste through leakage. Recycle of water should be done for reuse of water. Micro irrigation helps in lowering the water loss and hence saves water.

Key words: *Soil Management, Soil Erosion, Water Management, Afforestation, Mulching, Shelter Belt, Conservation Tillage*

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MANAGEMENT OF BIOTIC AND ABIOTIC STRESS IN LENTIL

Mohit[1*] and S.P.S. Sirohi[2]

[1]ICAR-Central Soil Salinity Research Institute, Regional Research Station, Lucknow, UP-226002, [2]Department of Genetics and Plant Breeding, Kisan PG College, Simbhaoli, Hapur, UP-245207

**Corresponding author email: mohitagro123@gmail.com*

Lentil (*Lens culinaris Medik.)* is a diploid (2n=2x=14), self-pollinating, cool-season, grain legume which is cultivated worldwide. Lentil, being rich in protein, minerals and vitamins, play a significant role in the nutritional security of Indian people, especially those below poverty line, who can ill-afford animal food products. However, per capita per day availability of pulses in India is about 47 g against the minimum

recommended dose of 70 g/capita/day. The productivity of lentil in India (Hd1008 kg/ha) is very low as compared to other countries. However, lentil production is constrained by biotic stresses such as ascochyta blight (AB), fusarium wilt, rust, stemphylium blight, anthracnose, and botrytis gray mold as well as abiotic stresses such as drought, water logging, high temperature, low temperature, salinity, and nutrient stress. Losses due to biotic and abiotic stresses in lentil vary from 30 to 100% depending on the magnitude of their severity. To ensure sustainable lentil production under the impacts of variable climate, integrated packages of practices are required for different areas of the country.

Key words: *Abiotic stress, Biotic stress, Integrated practices, lentil*

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ASSESSMENT OF BIOMASS, CARBON SEQUESTRATION POTENTIAL AND ECONOMIC YIELD IN PREVALENT AGROFORESTRY SYSTEMS OF UP

Sarvan Yadav[1], Bhalendra Singh Rajput[2], M. K. Singh[1], Sanjeev Kumar[2], Dinesh Gupta[2] and Nazir A. Pala[3*]

[1]Department of Agronomy (Agroforestry), Banaras Hindu University, Varanasi, [2]College of Forestry, Banda University of Agriculture and Technology, Banda (U.P)
[3]Faculty of Forestry, Benhama Ganderbal, SKUAST-K*

The present study was carried out in various prevailing agroforestry based land use systems in Mirzapurdistrict of Uttar Pradesh. The study focused on variation in biomass accumulation, carbon sequestration potential, carbon credit benefits and economic returns from seven different prevailing agroforestry systems. The results revealed that Mango + wheat (T_2) land use systems showed significantly higher above ground biomass (22.31 t ha^{-1}), whereas annual crop (T_7) showed significantly lowest (6.25 t ha^{-1}). Significantly highest below ground carbon sequestration (2.36 t ha^{-1}) is recorded under pure mango orchard (T_4) followed by mango + wheat (T_2) (1.85 t ha^{-1}). Highest amount of CO_2 sequestration potential was observed under mango + wheat (T_2) (47.73 t ha^{-1}) followed by pure mango orchard (T_4) (42.41 t ha^{-1}). Maximum carbon credit $ha^{-1}yr^{-1}$ was evaluated by annual crop as compared to other treatments. Irrespective of land use system, rate of gross return is maximum in mango + wheat followed by pure mango orchard. Significantly maximum benefit: cost ratio (5.76) was observed under mango + wheat (T_2) followed by pure mango orchard (T_4) and minimum (1.23) in annual crop (T_7). The study thus provides a feed back of different agroforestry systems (crop combinations) in context of biomass accumulation, credit accounting and benefit cost analysis for farming communities in future farming practices. The carbon sequestration potential of different crop combinations in the present study can serve an important aspect in changing global climatic conditions on livelihood impacts.

Key words: *Biomass, Land use, Economic benefit, Orchard, Climate change*

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IMPACT ASSESSMENT OF CHECK DAM ON IRRIGATION WATER AVAILABILITY AND SOCIO-ECONOMIC CONDITION OF FARMER IN MEJA TEHSIL OF ALLAHABAD DISTRICT

Rajat Mishra*, Arpan Sherring, Vishnu Ji Awasthi, Kaushal Shakya, Pankaj Singh Dangi and Rohit N Padyar

SWCE, SHUATS, Allahabad

A study on the performance of check dams was carried during 2016-18 in the Gadarnala watershed, which is located in Meja tehsil of Allahabad district. Check dams were built by the minor Irrigation Department of Allahabad in a drought-prone area of south Allahabad to prevent rainwater from flowing away into rivers. It provides sufficient amount of water for agricultural crops as well as domestic use, when rain fails to meet the water requirement, and also facilitate the recharging of surrounding groundwater through percolation in the study regions. The study was conducted i) to assess the impact of check dams on irrigation water availability by analyzing the storage capacity of a check dam at various storage depths and water requirements in various crops in growing season, and ii) to study the socio-economic condition of farmers in the study region. The water requirement of the various crops (like Wheat, Musterd and Paddy,) was calculated with the help of crop-evapotranspiration (ETc). Penman-Monteith method was employedfor the assessment of potential evapotranspiration of study area utilizing ten years mean metrological data. The socio-economic analysis was done by Focus Group Discussion (FGD) and Household Questionnaire (HHQ). The parameters like cropping system, cropping pattern, cropped area, crop production, household assets, economics, education pattern, migration pattern prior to and after the construction of the check dams were considered for the socio-economic analysis. The study reveals that average 31% increase in the irrigated cropped area was recorded as an impact of the construction of check dams. Average 32 and 51% increase was observed in total cropping area under wheat and paddy crops respectively. From the socio economic analysis it was found that, the 90 % of farmers have amended their roofs from mud to concrete, 64 % of farmers had changed their small mud huts to bigger houses made of bricks and average 56.33 % decrease in migration was observed from the farmers living in the nearby villages after the construction of dams. It can concluded from the study that, the check dam has better impact on agricultural as well as the socio-economic life of the peoples in the study regions.

Key words: *Storage, Evapotranspiration, Cropping pattern, Socio-economic*

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STUDY ON SOIL FERTILITY STATUS OF AONLA PLANTED AREA IN THE DISTRICT OF PRATAPGARH OF UTTAR PRADESH

P.K. Upadhyay*, P. Sirothia[1], A.K. Singh[2] and Y. Kumar[3]

** Research Scholar, [1]Associate Professor, MGCGV Chitrakoot Satna, MP*
[2]Scientist, [3]Program Assistant, KVK, Pratapgarh, UP

The study was conducted on the soil fertility status of the aonla planted area in the district of Pratapgarh of Uttar Pradesh. There are 17 blocks in the district but 5 block and Three villages from each block were selected On the Basis of Aonla orchard availability from each development block namely Patti, Belkharnath, Sadar, Sangipur, and Sanwa chandrika were selected for soil profile study. Three

representative soil profiles in each village were exposed. At each location 2-4 composite samples were taken from different horizons viz., 0-20, 20-40, 40- 60, 60-80, 80-100 cm segments. The result from the study showed that the organic carbon content of all the five block varies from low to medium. The available N content of each block were foundlow to medium and showed positive co–relation with the carbon content of the soil.The available Macro nutrient N P K & S value decreased with the depth.The available P content of each block was low to high. However, the P content of the Belkharnath block is higher than other four Blocks because of the higher content of organic matter availability. The available K contents of each block was moderate to high and among them Sadaris highest. This is the good indication for the high yield of vegetable, fruits and tuber crops which have high amount of K. The S content is found to be comparatively higher in the Sadar (Bhuwalpur) and Bababelkharnath Dham (Amerpur). The available Zn content is low to high. B content is higher in all the blocks. The various results obtained from the different oil test in the laboratory and collect the data about the nutrients status of the soil of the five blocks under study and based on these findings, a balanced recommendation of fertilizers and manures to various crop can be made that will help in increasing the productivity of different food crops and orchards.

Key words: *Soil fertility, Nutrient, organic carbon, Nitrogen*

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IMPACT OF HALOPHILIC BIOFORMULATIONS WITH DIFFERENT LEVELS OF NPK ON WHEAT CROP AND FERTILITY OF SODIC SOIL

Ratna Sahay[*1], A. K. Singh[1], Sanjay Arora[2], Archana Singh[1], R. C. Maurya[1], D.K. Tiwari[1] and Sunil Singh[1]

[1]Krishi Vigyan Kendra, Dhaura, Unnao, UP
[2] ICAR-Central Soil Salinity Research Institute, RRS, Lucknow, UP
**Corresponding author email: ratnaasahay@gmail.com*

A field experiment was conducted during the *Rabi* season of 2017-18 at KrishiVigyan Kendra, Unnao farm to study the impact of halophilic bio-formulations in sodic soil with different levels of NPK on different growth parameters of crop and soil fertility. Three NPK fertilizer levels (120:60:40, 90:45:30 and 60:30:20 kg NPK/ha corresponding to control, 100%, 75% and 50% RDF) with four bio-formulation treatments (Control, Halophilic Azotobacter Halo-Azo, Halophilic Phosphate Solubilizing Bacteria Halo-PSB and co-inoculation of Halophilic Azotobacter and Halophilic Phosphate Solubilizing Bacteria) were replicated three times in RBD. The growth parameters and yield attributes showed an increase with increase in the NPK fertilizer levels. 100% RDF with co-inoculation of bio-formulations Halo-Azo and Halo-PSB recorded significantly highest grain yield (43.50q/ha) and straw yield (67.50q/ha) over other treatments. The increase in grain yield was 10.4 %, 10.2% and 9.6 %, higher with the co inoculation of both the bio formulations at respective different NPK, RDF levels 100%, 75% and 50% over control. Significant changes were also reported in nutrient content of post-harvest soil *viz.,* available nitrogen and available phosphors as compared with un-inoculated fields. Chemical analysis of soil showed that the inoculation of Halophilic Azotobacter and Halophilic Phosphate Solubilizing Bacteria significantly increased the level of N and P in post-harvest soil, up to 10.5% and 8.5%, respectively. Inoculation of bio-formulations also decreased the pH of soil over control that shows the notable improvement in the sodic soil. All bio formulation inoculated treatments were reported with significant increase in the dehydrogenase activity of soil as compared to un-inoculated treatments. Greatest activity was reported with NPK, 75% RDF with co-inoculation of bio formulations. It has been observed that there is great scope of increasing crop yields through the use of Halophilic bio-formulations with different levels of

NPK. It is extremely important for sustaining production and improving the fertility of soils. Exploitation of these bio-formulations has enormous potential in utilization of unfertile sodic lands.

Key words: *Halophiles, Halo-Azo, Halo-PSB, Wheat, Sodic soil, NPK levels*

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EFFECT OF FERTILIZERS ON TURMERIC *(Curcuma longa)* AND GUAVA *(Psidium guajava)* YIELD UNDER AGRI-SILVI-HORTI SYSTEM ON PARTIALLY IMPROVED SODIC SOIL

S. K. Verma and O. P. Rao

Department of Agroforestry, Acharya Narendra Dev University of Agriculture & Technology, Kumarganj, Ayodhya (UP)

The present experiment was conducted at Main Experiment Station (26^0 27′ N latitude and 82^0 12′ longitudes at 113 m elevation from sea level), A.N.D.U.A.T., Kumarganj, Ayodhya (UP) during 2017-2018 to evaluate yield of *Curcuma longa* under *Psidium guajava* and *Casuarina equisetifolia* based agri-silvi-horti system in partially improved sodic soil**.** The trial was laid out in RBD design with four replications with five treatments. The maximum fresh weight of *C. longa* rhizomes (5.64 t ha^{-1}) and *P.guajava* fruit yield (6.52t ha^{-1}) were obtained in T_3(50% NPK+50% FYM) treatment in agri-silvi-horti system. The maximum fresh rhizome yield 6.59 t $ha^{-1}yr^{-1}$ was obtained in T_3(50% NPK+50% FYM) in open area followed by 5.62 t $ha^{-1}yr^{-1}$ in case of T_4(25% NPK+75% FYM).

Key words: *Sodic soil, Psidium guajava, Casurina equsitifolia, Curcuma longa, Fertilizer*

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INTEGRATED FARMING SYSTEM FOR DOUBLING FARMERS' INCOME

Y. K. Sharma[1], S.K. Mishra[2], Brajmohan[3] and Ravindra Kumar Rajput[4]

[1]Subject Matter Specialist (Agrl Ext), [2]Senior Scientist and HOD,[3]Subject Matter Specialist (Hort),[4]Subject Matter Specialist (Soil Science) KVK, Mathura

Integrated farming system approach is the way out to meet the objective of doubling farmer's income. The KVK Mathura too adopted horticulture based integrated farming system in one acre to demonstrate the farming community that how the outputs of one component is used as input for other related enterprises wherever feasible. Under this model a horticulture nursery is established and a high density lemon orchard of seedless variety was established with vermi-compost unit, a small dairy unit of 8 animals besides fodder production and backyard poultry. Diversified use of land and its use in related enterprises help farmers to raise their income. This model in 1.0 acre land is found suitable to increase farmer's income besides optimum use of resources.

Key words: *Integrated farming system, High density lemon orchard, Farmer's income*

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PERFORMANCE OF WHEAT VARIETY KRL-210 IN SALINE SOIL OF MATHURA DISTRICT

Ravindra Kumar Rajput[1], Y. K. Sharma[2], S.K. Mishra[2] and Brajmohan[4]

[1]Subject Matter Specialist (Soil Science), [2]Subject Matter Specialist (Agrl Ext), [3]Senior Scientist and HOD, [4]Subject Matter Specialist (Hort) KVK, Mathura

Mathura district of UP mainly have a problem of salinity. The saline specific wheat variety KRL-210 was assessed for local cultivation by way of conducting on farm testing by KVK Scientists in villages Ading (Goverdhan), NaglaGyashi (Mathura) and Jhandipur (Farah) on 5 farmers' fields under existing farming system. The result showed that the salinitytolerant variety KRL-210 gave higher yield (34.6 q/ ha) by 28.15% over local check (farmers variety) which recorded a yield of 27.0 q/ha.Besides the tolerant variety was found with profound tillering after 1st irrigation which was done after 30 days against the general recommendation of applying 1st irrigation after 18-22 days after sowing. Net return of local wheat variety was Rs. 14100/ha and KRL-210 26380/ha. B:C ratio was 1.41and 1.73, respectively.

Key words: *Salt tolerant wheat, Irrigation, B:C ratio, Net returns*

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POTENTIAL OF ORGANIC DAIRY FARMING IN ASSURING FOOD SAFETY AND QUALITY

Kalyan Mandi[1] and S. Subash[2]

[1,2]Department of Dairy Extension, ICAR-National Dairy Research Institute, Karnal, Haryana

Indian agriculture was based on traditional ways of farming (i.e. organic farming) until the middle of the last century. The Green Revolution ushered in India during 1960s and it has been the cornerstone of India's agricultural achievement, transforming the country from the stage of food deficiency to self-sufficiency. During the period, the production has increased four folds but, indiscriminate and excessive use of chemicals has put forth a question mark on the sustainability of agriculture which addresses social health, human health, environmental health and eco-friendly agriculture. To cope up with the negative impacts of intensive production systems on the environment the value of adopting more sustainable and environmentally friendly systems such as organic dairy farming has gone up. Organic dairy farming means feeding organic feed to dairy animals and providing them with access to pasture, along with restricted use of antibiotics and hormones. Although organic fruits, vegetables, grains and some livestock have been the cornerstones of organic movement for a long time, organic dairy is a relative newcomer. Organic dairy surged into the organic marketplace in the 1990s, establishing itself as a major category. With the increase in the awareness and health consciousness among consumers, demand for organic products including milk is increasing. The fact that most organic markets and consumers are in developed countries and are prepared to pay a premium for organic products makes organic farming a niche area with excellent prospects for exports. This review offers an insight into the various aspects of organic dairy including the advantages and the challenges we face today. Potential, constraints and opportunities were also discussed for the development of organic dairy farming.

Key words: *Organic, Dairy farming*

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WEEKLY PAN EVAPORATION MODELING USING DIFFERENT HEURISTIC TECHNIQUES

Suman Markuna[1*] and Pankaj Kumar[2]

[1]M.Tech Student, SWCED, College of Technology;*
[2]Assistant Professor, SWCED, College of Technology, GBPUAT Pantnagar-263145
Corresponding author email: sumansingh99sm@gmail.com

Modeling of pan evaporation is an essential part of planning, management, and development of water resources for the entire world. Water loss is the major issue, which significantly affects water resources. The study aims to investigate the accuracy of models MLR, MNLR, MARS, M5 Tree and Random Forest in the modeling of pan evaporation for significant management of water resources. The meteorological data were taken from the Crop Research Centre (CRC) Pantnagar, Tarai region of Uttarakhand state, India. The selection of most appropriate inputs among climatic variables to map evaporation by regression approaches taken using Gamma test. The independent variables are maximum relative humidity (Rh_{max}), maximum temperature (T_{max}), minimum temperature (T_{min}) and wind speed (W) & the dependent variable is observed pan evaporation (E). The modeling of weekly pan evaporation considered in two parts in training period for the year 2009-2011 and in testing period for the year 2012. The study focused on the performance of models to predict weekly pan evaporation by comparing the statistical parameters as root mean square error, coefficient of correlation and coefficient of determination. The positive effect of the accuracy of models observed when the dataset is divided into training and testing. The lower value of root mean square error (RMSE) indicated that the model predicts the values in greater accuracy and precision. The RMSE is lower for the Random Forest model for both the periods than other models used in the study. The coefficient of correlation (R) & coefficient of determination (R^2) for Random Forest model in training period 0.994 &0.987 and in testing period 0.988 & 0.975. The results indicated that the Random Forest model is efficient for modeling of pan evaporation.

Key words: *Pan evaporation, MLR, NMLR, MARS, M5 Tree, Random Forest*

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ACTIVATED CHARCOAL FROM AGRICULTURAL BIOMASS: AN ALTERNATIVE METHOD FOR *IN-SITU* REMEDIATION OF CR(VI) CONTAMINATED GROUNDWATER

Divyanshu Bhatt[1*], Deepak Kumar[1] and Brijesh Kumar Yadav[2]

[1]M. Tech Student, SWCED, College of Tech., [1]Assistant Professor, SWCED, College of Tech., GBPUA&T Pantnagar-263145,*
[2]Associate Professor, Department of Hydrology, IIT Roorkee-247667
**Corresponding author email: divyanshubhatt181@gmail.com*

Groundwater contamination is one of the major problem in industrial areas of India. Groundwater contamination includes volatile pollutants as well as a persistent pollutant. Groundwater contaminated with heavy metals can be categorized as a persistent pollutant. Persistent pollution due to chemicals such as Arsenic, lead, chromium, cadmium, etc. has also been observed in many places in India. The rapid groundwater pollution is a serious threat for humans, crops and all living organisms of the earth. To remediate contaminated groundwater both *ex-situ*, as well as *in-situ* methods, can be adopted. *Ex-situ* methods are relatively costly and this method can't stop the moving contaminated plume to move in

the direction of groundwater flow. *In-situ* remediation has the potential to stop the contaminated plume to move in the direction of groundwater flow. This is one of the advantages due to which technology is widely accepted for groundwater remediation. In the present work, *in-situ* remediation of contaminated groundwater has been elaborated with activated charcoal. Activated charcoal is generally a fine black powder which is made from bone char, coconut shells, peat, petroleum coke, coal, olive pits or sawdust. The charcoal is "Activated" by processing it at high temperatures (500-700^{0}C) and by the chemical activation process. The application of high temperatures and chemical action on charcoal changes its internal structure, form large numbers of pores and increasing its specific surface area. Charcoal prepared from wheat, rice husk, rice straw, maize residue and pine, which is efficient, economical and easily available, may also be used for *in-situ* remediation of contaminated groundwater. The basic principle of adsorption is used to deposit heavy metals on the amorphous layered surface of activated charcoal. *In-situ* bioremediation is a relatively new technology that has great promise for improving the remediation of groundwater.

Key words: *Activate Charcoal, In-situ remediation, groundwater*

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EVALUATION OF INTERCROPPING (LEMONGRASS WITH POMEGRANATE) AT DIFFERENT TREATMENT LEVELS

Mithun Kumar, Anupama, Puja Khare*, Sudhir Kumarand Alok Krishna*****

**Agronomy and Soil Science Division, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015,*
***Horticulture Division, Central Agroforestry Research Institute, Jhanshi-284001,*
****Technology and Business Development Division, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015, India*

Intercropping is a multiple cropping system that allows two or more crops planted in a field during a growing season. Intercropping is a way to increase diversity in an agricultural ecosystem. Ecological balance, more utilization of resources, increase in the quantity and quality of products are advantages of intercropping. The aim of study was to generate basic information about the effect of treatments on growth and yield of pomegranate and biomass and oil yield of lemongrass. The experiment was designed in CRBD with two cultivars of pomegranate (V_1- Ganesh and V_2- Bhagwa), lemon grass (Krishna) and three levels of fertilizers. The first harvesting of lemongrass (after four months of planting) was recorded from 0.93 to 2.82 kg leaves per plot having oil 1.07 to 1.1 percent on fresh weight basis. In second harvest of lemongrass, higher oil yield (49.15 kg/ha) and biomass 10.15 t/ha (T_1V_1) was recorded. The pomegranate fruit numbers were also increased in the same treatment. The study revealed that intercropping of lemongrass with Ganesh variety of pomegranate showed more promising results.

Key words: *Intercropping, Ecosystem, Pomegranate, Cultivars*

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EVALUATION OF BIOLOGICAL HEALTH OF ACIDIC MINE AFFECTED SOIL THROUGH PHYTOREMEDIATION BY AROMATIC CROP

Ranu Yadav, Shilpi Jain and Puja Khare*

[a]*Agronomy and Soil Science Division, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015, India*
**Corresponding author email: kharepuja@rediffmail.com*

During mining operations overburden materials are dumped in improper manner without any consideration for the respective consequence on soil profile. Mining can have adverse effect on soil quality due to unnaturally high concentration of chemicals such as sulphuric acid, arsenic and mercury etc. Toxic pollutants from mine gets released into the environment creating severe environmental pollution. In present investigation geranium (*Pelargonium graveolens* L) was selected for revegetation and amelioration of acidic mine spoil. It is an essential oil bearing aromatic cropand is the source of highly valuable geraniol and citronellol content. The remediation of acidic mine soil and their effect on enzymatic (alkaline phosphatase, acidic phosphatase, dehydrogenase, β-glucosaminidase, urease) and microbial activities were analyzed. For investigation geranium plant cultivation was done with proper ratio of soil and mine spoil (mine spoil-100%, mine spoil 75: soil 25, mine spoil 50: soil 50). After 90days of geranium plantation, organic content (carbon, nitrogen, phosphorus) and enzymatic activities were enhanced in all treatments. TRFLP assessed result were showing that microbial biomass varied from 70 to 260 ppm and 157 to 304 ppm of mine spoil soil at 0day and 90 days. The outcome of the study indicates beneficial effect of the geranium planting on soil enzymatic profile and restoring the soil fertility.

Key words: *Revegetation, Geranium, Acidic mine*

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PARADIGM SHIFTING OF Pb AND Cd FRACTIONATION IN SOIL BY BIOCHAR AND REDUCTION IN THEIR ACCUMULATION IN MEDICINAL PLANTS

Nidhi Nigam, Mohd. Ahsan, Versha Pandey and Puja Khare*

[a]*Agronomy and Soil Science Division, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015, India*
**Corresponding author email: kharepuja@rediffmail.com*

Heavy metal contamination in medicinal herbs is the major issue for their safe consumption worldwide. The aim of this study was to evaluate the ameliorating effect of biochar on the risk associated with the cultivation of medicinal crops in metal contaminated soil as well as understand the relation between the Pb and Cd content in different fractions of soil with their uptake. A greenhouse experiment was performed for three medicinal crops grown in Pb and Cd spiked soil with and without biochar. The different fraction of Pb and Cd were determined using European Community Bureau of Reference (BSR) methods. The fractionation of Cd demonstrated that maximum percentage of Cd present in the water-soluble or highly exchangeable (FA) fraction followed by reducible (FB) fraction. The biochar amendment significantly decreases the water-soluble or highly exchangeable (FA) fraction of Cd and water-soluble or highly exchangeable (FA) and reducible (FB) fraction of Pb. Results suggests that bioavailable fraction significantly decreased at higher biochar application rate. The translocation factor obtained in the present study for all crops reflects that Pb and Cd were largely retained in the root. Results showed that biochar inclusion in soil reduces the metal uptake from 60 to 95%. The biochar amendments were more effective

for *Withania somnifera*.The regression model implied that fractionation of metal can be used for the prediction of metal accumulation in these medicinal herbs.

Key words: *Biochar, Heavy Metals, Medicinal Crops, Accumulation*

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IMPACT OF CULTIVATION OF *Cymbopogon flexuosus* ON SOIL PROPERTIES OF RAIN-FED AREAS OF BUNDELKHAND

Priyambada Singh, Paurabi Das, Raghavendra Pratap Singh, Alok Krishna and Puja Khare

CSIR-Central Institute of Medicinal and Aromatic Plants, Agronomy and Soil Science Division, Lucknow-226015

Cymbopogon flexuosus (Nees ex Steud) commonly known as lemongrass, is one of the commercially important perennial aromatic grass. It is cultivated in Western Ghats, Kerala, Karnataka, Uttar Pradesh and besides the foothills of Arunachal Pradesh and Sikkim. At present India grows in about 3000 ha area and its annual production ranges between 300-350 tonnes/ annum. Lemongrass oil has been reported to have therapeutic activities such as sedative, carminative, soothing, analgesic and antimicrobial properties. The citral compound synthesized in lemongrass is attributed by its insect repellant, insecticidal, bactericidal and antifungal activities. Lemongrass can withstand a wide range of soils and climatic conditions. Grasses are usually tolerant to several abiotic stresses, check soil degradation and prevent desertification. It also increases soil carbon sequestration thereby enhancing soil microbial community. In present scenario the world is facing serious shortage of water for irrigation, especially in arid and semi-arid regions suffering due to over exploitation of water and irregular rainfall. In this study lemongrasses were grown in rainfed regions of Bundelkhand which has strengthen the soil properties. Results indicate that the cultivation of lemongrass has improved the chemical properties of soil such as pH and organic carbon (about 40% increase). It has also supplemented enzymatic activities of soil such as soil microbial biomass, β-glucosidase, acidic phosphatase and alkaline phosphatase. Due to extensive root system of lemongrass and its sequestration of soil nutrients, it harbors microbial communities which gradually become resilient to abiotic stress such as water scarcity. Soil micro-organisms play an important role in nutrient cycling and storage in terrestrial ecosystem. In this study the relative abundance of Proteobacteriain soil is highest (50-93%) followed by Firmicutes(6- 24%), Acidobacteria (6.20-16%) and Actinobacteria (0.5-5.2%). Proteobacteria defines nitrogen metabolism, iron and sulphur metabolism in soil whereas, Firmicutes are copiotrophs. Acidobacteria are responsible for carbohydrate metabolism while Actinobacteria for degradation of more complex organic materials and biological buffering of soil. Thus, cultivation of lemongrass in rainfed areas can be a helpful measure to overcome the water crisis along with improvement of soil properties.

Key words: *Cymbopogon flexuosus, Lemongrass, Rain-fed, Soil enzymes, Proteobacteria*

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PROMOTION OF INTEGRATED FARMING SYSTEM FOR DOUBLING FARMERS' INCOME

A.K. Singh[1], C.K. Tripathi[2] and J.B. Singh[3]

[1]Scientist (Agronomy), [2]Scientist (Ag. Ext), [3]Sr. Scientist/Head ICAR –KVK-1, Sultanpur

In UP about 87% farmers are in marginal to small farmer's category. The low asset base and poor resource management leads to risk and impede farmer's decision making ability about selecting the agricultural enterprises combinations. Cropping intensity which is main source of growth in agriculture

is found higher in marginal holdings and declines with increase in farm size. There was inverse relationship between farm size and farm productivity in recent years. Improving the productivity of small holdings is the need of the hour. Incorporation of diverse agri-enterprises which can be complimentary while contributing to the income improvement of small farmers is needed. Thus demand for development of an IFS approach able to sustain production system and doubling the income of farmers is increasing.IFS is an approach to minimize the risk, increase the productivity and doubling farmer's income by improving utilization of crop residues and organic waste as input in agricultural production. Economic viability of IFS module revealed that there is positive combination of diverse agri enterprises which will increase system productivity, profitability and sustainability in term of money and quality food. The economic feasibility of IFS is directly linked with doubling farmers' income. The IFS module for farmers with one hectare land holding was developed by KVK-1, Sultanpur as depicted:

IFS module (1.0 ha)

1-	Crop production (Paddy-Wheat-Urd)	0.5 ha
2-	Animal husbandry (3 milch cows)	0.25 ha
3-	Fishery + Duckery	0.25 ha
	Total area	1.0 ha.
	Total cost of production	Rs. 230300
	Total income-	Rs. 602500
	Net income-	Rs. 407200
	CBR	1:2.62

Thus, IFS module is able to sustain agricultural production, farmer's income, safe guard the environment and respond to consumer concerns about food quality, which is the basic concept of IFS.

Key words: *IFS module, DFI, Sustainable agriculture*

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PREPARATION OF VERMICOPMPOST BY USING DIFFERENT WASTE MATERIALS

Amar Singh[1*], Deo Kumar[2], Jagannath Pathak[3], Arbind Gupta[4] and Veer Singh[5]

[2]Assistant Professor; [3]Associate Professor, [4]Assistant Professor, [1]M.Sc. (Ag) Student, Department of Soil Science and Agricultural Chemistry, Banda University of Agriculture and Technology, Banda, 210001, [5]M.Sc. (Ag), Department of Plant Pathology, CSAUA&T, Kanpur, 208002

**Corresponding author email:amarsingh2617@gmail.com*

Application of Vermi-compost improves the physical, chemical and biological properties of soils. Vermi-compost is a richersource of plant nutrients than theother types of organic sources. In general, the average nutrient content of vermi-compostis1.5 % N,0.4 % P_2O_5 and 1.8 % K_2O with pH range of 7.0-8.0. The nutrient level varies with type of materials used for vermi-composting. Keeping in view the importance of Vermi-compost an experiment was conducted on vermi-composting at College of Agriculture, Banda University of Agriculture &Technology, Banda during 2019. There were three treatments viz. T_1 (Cow dung), T_2 (Cow dung + Carton at 1:1 ratio) and T_3 (Carton) by using Earth worm species *Eiseniafoetida*. The experimental pit size was 2.5 m long, 1 m width and 0.5 m depth using raw material 1 quintal. The results revealed thatvermi-compost was prepared in treatment T_1in 57 days followed by T_2 in 73 days and T_3in 135 days after releasing of earth worms.

Key words: *Vermi-compost, Eisenia foetida, Cow dung, Carton*

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EFFECT OF SULPHUR APPLICATION ON SULPHUR USE EFFICIENCY AND PRODUCTIVITY OF BLACK GRAM

Sandhya Fariya, J. K. Tiwari*, Jagannath Pathak and Amit Mishra

Department of Soil Science and Agricultural Chemistry, Banda University of Agriculture and Technology, Banda, 210001 (UP) India

**Corresponding author email: jtiwarikishor@gmail.com*

Modern intensive farming and application of higher fertilizer doses resulted in removal of all the essential nutrients in higher proportions by the crops. Most of our attention for fertilizer use has been restricted to the use of N, P and K, the three primary nutrients required by the crops in large quantities. S is one element that must not be overlooked. Pulses are important commodity group of food crops that can play a vital role to address national food and nutritional security and tackle environmental challenges. Pulses are a smart food as these are critical for food basket (dal-roti, dal-chawal), rich source of protein i.e. 20-25 per cent which is double the protein content of wheat and thrice that of rice and help address obesity, diabetes malnutrition etc. Increase in pulse production is urgently needed to meet up the demand of the people to reduce import, to save foreign currency. Blackgram is a major pulse crop of *Kharif* season in Banda district of UP. An experiment was carried out in *Kharif* season of 2019, to assess the response of two sulphur sources (elemental sulphur and single super phosphate) and four levels of application (0, 15, 30, and 45 kg S/ha) in blackgram crop cv Azad -3 at student experimental field of Banda University of Agriculture and Technology. The experiment was conducted in RBD with eight treatments and three replications. The biometric observations viz, plant height, number of pods per plant, number of seeds per pod, test weight(g), grain and stover yield (kg per ha) were recorded and sulphur use efficiency including post-harvest status of NPK and S also evaluated. Mean value of data indicated that, application of recommended dose of NPK and 30 kg S per ha resulted in better grain yield (850 kg per ha) with other yield attributing characters such as number of pods per plant, test weight. SSP proved superior over elemental sulphur from nodulation and productivity point of view. However, application of 30 kg S per ha was promising in terms of S use efficiency and economic return. The economic analysis indicated that application of 30 kg S per ha along with RDF registered the maximum net return in blackgram crop.

Key words: *Sulphur, Use efficiency, Net return, Yield, Blackgram*

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DOUBLING THE FARMERS' INCOME THROUGH MAIZE-PIGEONPEA INTER-CROPPING ON PERMANENT BED SYSTEM

Pradeep Kumar[1] and Gharsiram[2]

M.Sc. (Agronomy) student, Dr.RPCAU,Pusa, Samastipur, Bihar(848125)

Corresponding author email: lalpradeepkumar72@gmail.com

This field experiment was conducted at Research farm TCA, Dholi, Bihar in 2018-19, this region comes under the highly populated regions of India having extreme density of poverty and malnourished people. It is one of the most vulnerable regions in term of climate change induced variability and hence has serious implications for food security and economy. Increasing population, regularly decreasing land availability and natural resources are the major threats. To overcome this problem a maize-pigeon-pea intercropping system experiment was done as India's 15 M people grow maize and it is third largest

cereal crop and pigeon-pea is second largest pulse crop. Maize is less water demanding and gives higher yield per hectare, by growing maize farmers save 90% of water, 70% of power compared to paddy and including the pigeonpea crop in cropping system sustain the soil health, fertility and increases the soil organic matter and nutrient availability status of component crop and to next crop because it has high foliage biomass and leaf litter. In this experiment maize – pigeon-pea was planted in 2:2 ratio ofrows. This system is widely used in different countries particularly for wheat and has seldom been studied in maize – pigeon-pea intercropping system. Study was conducted to evaluate the permanent bed (PB) vis-à-vis the zero tillage, fresh bed and conventional tillage system of planting at varying NPK fertilizer doses in the system. In terms of soil organic carbon, nutrient status, plant population, plant height, no. of cobs/ plant, test weight, no. of pods/ plant, grain yield, MEY, and B:C ratio. In permanent beds the soil organic carbon after harvesting of crop ranged from 0.49-0.59 % compared to conventional tillage ranging from 0.39-0.45 that mean low OC in conventional tillage plot. Nutrient status in respect of NPK in permanent beds ranged from 270.3-298.9, 22.1-29.6 and 69.5-98.2 kg/ha compared to conventional plot that ranged from 235.6-258.6, 19.6-21.5 and 45.9-55.5 kg/ha. ANOVA for adjusted mean revealed significant treatment effect for yield and economic analysis parameters for maize-pigeon-pea intercropping. Maize and pigeonpea yields across the tillage treatment ranged from 40.65 and 17.34 q ha^{-1} and MEY 98.46 q ha^{-1} under conventional tillage to 58.26, 20.15 and 125.46 q ha^{-1} PBs. Compared to conventional tillage the average maize and pigeonpea grain yields across zero tillage and fresh bed has greater 37.02, 6.57 and 12.42, 1.44% respectively. Maize and pigeon pea intercrop B:C ratio was 2.61 in conventional and 3.60 under PBs. It can be concluded that under permanent bed system higher grain yield and MEY and B:C ratio was obtained over the fresh bed, zero tillage and conventional tillage. We also conclude that both maize and pigeonpea planted on permanent bed and zero tillage can result in higher B:C ratio compared to conventional tillage practices.

Key words: *Conventional tillage, zero tillage, B:C ratio*

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EX-SITU RAINWATER HARVESTING IN LOW LYING AREA FOR DEVELOPMENT OF LITCHI BASED CROPPING SYSTEM

Vishal Nath, R.K. Patel, A.K. Gupta and Ramashish Kumar

ICAR-NRC for Litchi, Mushahari, Muzaffarpur (Bihar)

Water is one of the most important natural resource for all kinds of life on the earth. Approx 70% of the earth surface covered with water. Nearly 20% of all the water used in the world obtained from ground water resource and agriculture is the largest user of water accounting for 80% of all the consumption. Rising population, urbanization, industrialization and modernization of agriculture are the main reason of water shortage in many part of the country. Rainfall water conservation and its management is one of the potent strategies to conserve and utilize water to meet current and future demand.

At ICAR-NRCL approximately 8 ha. low lying area remain underutilized due to seasonal water logging and predominance of aquatic weeds which has been utilized sustainably by land shaping into ridges and furrow system. Litchi plantations done on ridges (8mx4m) and in deep furrow areas short duration fishes and seasonal crops were grown. Based on season, paddy was cultivated, as *Kharif*, wheat as *Rabi* and moong bean, bottle guard and pumpkin in summer. Deep furrows were allowed to stagnate water 80-90 cm and the over flow water was conserved in inter connected ponds having depth (3-4 m) which was used for fish production and irrigation during *rabi* season. A yield level of Paddy to the tune

of 3.25-3.30 t/ha., Wheat 2.40-2.50 t/ha., Pumpkin 1.80 t/ha., Bottle gourd 10.8 t/ha. and Moong bean 1.90 t/ha. was recorded during 2018-19. The average yield recorded under normal low land area in the crops were 3.05-3.10 t/ha., 2.30-2.40 t/ha., 1.55 t/ha., 10.2 t/ha. and 1.83 t/ha, respectively. Therefore it was found that performance of different seasonal crops grown in deep furrows land system was better yield than normal low land. The ponds builds have been used for raising Litchi, Banana and Papaya.

Key words: *Ex-situ, Low lying, Litchi, Cropping system, Rainwater*

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IMPACT OF CARBON SEQUESTRATION ON MITIGATING CLIMATE CHANGE AND SOIL BIOLOGY

Gharsiram and Pradeep Kumar

Dr. RPCAU Pusa, Samastipur, Bihar 848125

Human activities, especially the burning of fossil fuels such as coal, oil, and gas, have caused a substantial increase in the concentration of carbon dioxide (CO_2) in the atmosphere. This increase in atmospheric CO_2 from about 280 to more than 380 parts per million (ppm) over the last 250 years is causing measurable global warming.CH_4 and N_2O concentration are increasing primarily due to dairy and agriculture. Agricultural activity is responsible for about 70% of anthropogenic N_2O emissions (World Bank, 2015) and 40% of CH_4 emissions globally (World Bank, 2015). These greenhouse gases have significantly higher radioactive forcing and longer atmospheric residence times than CO_2. Carbon is part of the natural carbon cycle, and the world's soils holds around twice amount of carbon that is found in the atmosphere and in vegetation. Organic carbon gets assimilated within the plant system through photosynthesis using carbon dioxide from the air and water. The vegetative parts, animals, human and other living being once dead return to the soil where they are decomposed and recycled. It increases agricultural production with enhanced soil physical, chemical and biological properties and facilitate environmental benefits leading to improved food system stability to fight world hunger. The primary way to sequester carbon in the soil is to add organic soil amendments such as compost or animal manures. Soil organic matter is a complex of carbon compounds, and includes everything in or on the soil that is of biological origin. It includes plant and animal remains in various states of decomposition, cells and tissues of soil organisms, and substances from plant roots and soil microbes. Combination of NPK+FYM have good potential in C sequestration in Indian soils and mitigating GHG_S emission without any additional cost. Agro forestry is important as a carbon sequestration strategy because of carbon storage potential in its multiple plant species and soil as well as its applicability in agricultural lands and in reforestation. Average carbon sequestration by agro-forestry practices has been estimated as 9, 21, 50 and 63 MgC/ha in semi-arid, sub-humid, humid and temperate regions. For small holders agro forestry systems in the tropics, potential C sequestration rates range from 1.5 to 3.5 Mg C/ha/yr. Soil microorganisms play a crucial role in the carbon sequestration process by transforming plant residues into smaller carbon molecules that are more likely to be protected and sequestered. The microorganisms are responsible for processing larger pieces of plant residues into smaller forms that can be metabolized by smaller organisms such as fungi and bacteria. At each point on this decomposition pathway, different types of carbon of differing size and chemical complexity are produced that can be associated with silt and clay particles or incorporated into soil aggregates.

Key words: *Agro forestry, C sequestration, microorganisms*

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IMPACT OF RESOURCE CONSERVATION AGRICULTURE TECHNIQUES ON WATER USE EFFICIENCY AND WEED CONTROL IN MAIZE

Abha Devi and Gharsiram

Dr. RPCAU Pusa, Samastipur, Bihar- 8481252

Maize (*Zea mays* L.) is one of the important cereal crop in India having wide adaptability to soil and diverse agroclimatic conditions and under different cropping sequences. As per 3rd Advance Estimates, the estimated production of maize crop in India during 2018- 19 is 27.82 million tonnes. The increasing demand for food security along with increasing population has led the researchers and agriculturists to introduce resource conservation technology in food grain like maize. Recent research has shown that the RCTs bring many possible benefits including reduced water and energy use (fossil fuels and electricity), reduced greenhouse gas (GHG) emissions, soil erosion and degradation of the natural resource base, increased yields and farm incomes, and reduced labor shortages (Pandey *et al*., 2012). The treatment including combination of hairy vetch grass and zero tillage has resulted lowest weed cover rate and weed dry biomass i.e. 5.6 % and 79.0 kg/ha respectively. Even a treatment combination including hairy vetch, zero tillage and half recommended fertiliser dose recorded higher maize yield (0.60 t ha^{-1}) which was superior over a treatment including natural fallow with recommended fertiliser. Beside all this, inclusion of cover crop as a resource conservation technique protects soil surface against raindrop energy hence, contributes in reducing runoff and also nutrient losses from soil that makes it unproductive. Drip irrigation and mulching has positive effect on grain and stover yield but has negative effect on weed population. In stale seed bed as RCTs the density and dry weight of grasses and broad leaved weeds are reported lowest. Tied ridge and flat-bed method of RCTs gave WUE of 5.66 and 5.65 kg/ha/mm, respectively (Okbagabir *et al*.,2017). The highest values of SOC (12.77 and 12.82 g kg^{-1}) statistically with a highest increase of 3.99 and 4.40% in 0-40cm in soil depth were recorded under zero tillage treatment (Asenso *et al*., 2018). It has been that reported about 36% water saving for broad-beds and about 10% for narrow-beds compared to flat sowing, and 6% increased grain yield of wheat and 33% of maize (Akbar *et al*., 2007). In both cases, the furrows act as pathways for drainage during excessive rains and conserve rainwater in dry spells. The RCTs also includes saving money of farmers and using the alternatives that can help to reduce the expenditures. Hence, no- tillage as a resource conservation technique not only conserves the soil and water but also reduces the capital investment in machinery for land preparation and intercultural operations. The inclusion of cover crop also contributes in reducing expenditures by suppressing weed growth, hence, cutting the need for use of weedicides that may cost very high. The use of rotavator saves expenditure up to 60% and 25% makes the soil conditions favourable for maize by minimum soil compaction with mould board plough in comparison with other treatments including cultivator two or three times along with planking.

Key words: *Tied ridge, Flat-bed method, RCTs, no-tillage*

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SAVE WATER, SAVE FUTURE

Sachin Tiwari*

Research Scholar, Amity University, NOIDA campus
**Corresponding author email: Tiwari.sachin766@gmail.com*

Rainwater harvesting is a unique technique to save the water from rain, which otherwise, usually gets wasted by other means. In several parts of India, this method is being used to deal with the water scarcity issues. Rainwater Harvesting is one of the most commonly used methods to save water. It refers to storing of rainwater for various uses. The notion behind rainwater harvesting is to not waste the rainwater and prevent it from running off. In other words, it is done to collect rainwater using simple mechanisms. This method helps people to get water which is clean, free of cost and save it for later use. As we know that surface water is not enough to meet the demands of the people, we can get additional help from rainwater. Also, most people now depend on groundwater for their uses. Many houses and even flats have submersible pumps in their place. The groundwater is decreasing day by day because of excessive usage, deforestation, urbanization etc. Instead of groundwater, we can use rainwater to meet these needs too. Rainwater harvesting is a very simple method that can be practiced by anyone. There are primarily two types of rainwater harvesting methods. The first one is surface runoff harvesting. In this method, the water that runs off the surface is focused on. Second, we have rooftop rainwater harvesting. Here, the roof of a house or building works as a rainwater collection unit. It includes equipping the roof with pipes that direct to a pit or tank. These pipes will divert the water falling on the roof in the tank to save water from falling off. This is a very economical and efficient way to harvest rainwater. This efficient technique must be used by everybody, so that we can be left with lesser issues regarding the water scarcity in many places of our country.

Key words: *Deforestation, Urbanization, Submersible Pumps, Equipping, Water Scarcity*

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RAINWATER HARVESTING AND GROUNDWATER RECHARGING

Himanshu Harit*, Iska Srinath Reddy, Aditya, Guruvelli Tarun Yeja and Arun Alfred David

Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbttom University of Agriculture, Technology and Sciences, Prayagraj 211 007, (UP), India
**Corresponding author email: himanshuharit28@gmail.com*

Every year in monsoon our nature gives us our life in the form of rainfall but little bit of it is stored in the soil, damps, lakes etc. and remaining water get wasted in rivers. At the time of rainfall, we don't recognize that running water. At the rate in which Indian population is increasing, these will lead to high rate of consumption of most valuable resource "water". After years of the rising population practices that increase demand of water supply have growing industries and the expansion of agriculture. Monsoon is still the main hope and the source of our agriculture practices. Now-a-days we are reaching the heights of development and covering all the earth surface by cement and concrete material but we are forgetting that we are closing the route of water to get entered in the surface of earth and its direct effects on our ground water level and we need to face water scarcity. This condition goes on then our new generation will face a high-water problem for drinking and agriculture purpose. Therefore, water saving becomes need of the time. During monsoons lots of water goes waste into gutters, drains. The rainwater harvesting is the simple collection or storing of water through scientific techniques from the

area where the rainfalls. It involves utilization of rain water for the domestic or agriculture purpose. The method of rain water harvesting has been into practice since ancient times. The method is simple and cost effective too. Rain water harvesting proves to be the most effective way to conserve water. We can collect the rain water into the tanks and prevent it from flowing into drains and being wasted. Rain water harvesting comprises of storage of water and water recharging through the technical process.

Key words: *Rain water harvesting, Ground water recharge*

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ACUTE AND CHRONIC EFFECT OF VITAMIN C ON GROWTH PERFORMANCE OF FRESHWATER CATFISH *(Heteropneustes fossilis)* UNDER PESTICIDE STRESSOR

Sneha Verma[1]* and Anurag Rawat[2]

[1]Department of Applied Science and Humanities, Invertis University, Bareilly
[2]ICAR-National Bureau of Fish Genetic Resources, Lucknow
**Corresponding author's email: sneha.v@invertis.org*

The objective of present work was to understand the effects of vitamin C on fish growth performance under the influence of pesticide stress. For this experiment, two separate experiments, one short and one long-term, were conducted whereas, short term for determination of acute concentration of chlorpyrifos (CPF) and long-term experiment for elucidating the mitigating role of vitamin C on CPF induced stress of *Heteropneustes fossilis*. In the short-term study, fishes were exposed to different concentration of CPF for 24, 48, 72 and 96 h. In the long-term study (15 days), fish were treated with different dose of vitamin C (1, 1.5, 2, 2.5 and 3%) to elucidate the mitigating role against CPF induced stress on*H. fossilis*. The effect of CPF on anti-oxidative enzymes activity in presence of vitamin C was observed. All the parameters were significantly influenced ($p < 0.01$) in dose and time dependent manner. Results showed that vitamin C enhanced growth performance of exposed experimental fish group. The present study concluded that due to pesticide exposure, unbalanced metabolism and damage of organs occurred but vitamin C inclusion as nutritional supplements have a potential to mitigate the induced stress.

Key words*: Heteropneustes fossilis, Growth performance, Stressor, Vitamin C*

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WATER QUALITY ASSESSMENT OF BHEEMTAL FRESHWATER LAKE SITUATED IN KUMAON REGION OF UTTARAKHAND

Ayushi Agarwal[1*], Aditi Lohumi[1], Himanshu Chaubey[1] and Deepak Kumar[2]

[1]B. Tech Agricultural Engineering, College of Technology, [2]Assistant Professor, Deptt. of Soil & Water Conservation Engineering, GBPUA&T Pantnagar
**Corresponding author email: ayushiagarwal1408@gmail.com*

Lakes are one of the major sources of fresh water on Earth. Bheemtal is one such lake situated in Nainital district of Uttarakhand. Nainital district is in the Kumaon region of Uttarakhand. BheemtalLake is basically famous as tourist place for its picturesque views. Every year thousands of tourists from every corner of India visit here. In this study, the water quality of BheemtalLake has been assessed. The data of water quality has been taken from Uttarakhand Pollution control board. The assessment was done from 2014 to 2019. The parameters of water quality assessment was pH, Biological Oxygen Demand (BOD),

Chemical Oxygen demand (COD), temperature, Conductivity, Dissolved Oxygen (DO) level, alkalinity, chloride, magnesium, hardness and total dissolved solids. The results suggested that pH was near 6.5 during the study period. BOD of lake water was close to 1.5 ppm, while COD was close to 5.5 ppm. The average temperature of lake water was close to 14 ^{0}C. The water temperature was lowest during the December- January period and maximum during May- June period. The conductivity of lake water has an average value of 220 ìmhos/cm. The DO level has an average value of 7.5 ppm. For the study area, alkalinity, chloride, magnesium, hardness and total dissolved solids has an average values of 130ppm, 20 ppm, 50 ppm, 120 ppm and 140 ppm, respectively. The results suggested that although the water is not fit for drinking, but it was of adequate quality for aquatic plants and animals.

Key words: *Bheemtal Lake, Water quality, BOD, COD*

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TEMPORAL STUDY OF GREENHOUSE GAS EMISSION FROM MAIZE RESIDUE BURNING IN INDIA FROM 1961 TO 2017

Aditi Lohumi[1*], Ayushi Agarwal[1], Himanshu Chaubey[1] and Deepak Kumar[2]

[1]B.Tech Agricultural Engineering, College of Technology, [2]Assistant Professor, Deptt. of Soil & Water Conservation Engineering, GBPUA&T, Pantnagar

[1] Corresponding author email: aditi17lohumi@gmail.com*

Residue burning has become one of the major environmental concerns in the last few years. InIndia, residue burning is concerned with air pollution which can cause respiratory illness in citiesand towns. Residue burning increases greenhouse gasses in the environment which in turn leads toglobal warming. With residue burning methane, nitrous oxide and carbon dioxide gasses canincrease in the troposphere. Maize is one of the chief crops in India and is considered a majorcereal crop in our country. After harvest of maize, the byproducts of the crop are used forfeeding livestock and the rest of the residue is burned either in the field or burned during cooking. In this study, the biomass of maize burned and the amount of methane, nitrous oxide and carbondioxide emitted from byproducts of maize has been studied. The study has been done for timeseries data from 1961 to 2017. The data has been taken from Food and Agriculture Organization (FAO). The results suggested that during the study period, the production of maize in India increased from 0.96 t/ha in 1961 to 3.11 t/ha 2017. In the period under consideration, the biomass of burned maize increased from 45 million tonnes to 92 million tonnes. Thebiomass of maize has increased up to 104% as compared to 1961. The results suggested that duringthe study period, the emission of methane, nitrous oxide and carbon dioxide gases also increasedmonotonically by the same amount as that of biomass production.

Key words: *Green House Gases, Maize residue, Air pollution*

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SEASONAL OCCURRENCE OF PLEROCERCOID LARVA OF PROTEOCEPHALUS SP. (CESTODA: PROTEOCEPHALIDAE) INFECTING SPOTTED SNAKEHEAD FISH *Channa punctata* (BLOCH, 1793) FROM MEERUT DISTRICT (UP), INDIA

Deepika* and Bindu Sharma

Department of Zoology, Chaudhary Charan Singh University, Meerut (UP) India

**Corresponding author email: deepikacam2707@gmail.com*

Fishes are the intermediate host of cestode larval stage. The aim of the present study was to measure the seasonal occurrence of plerocercoidinfection in *Channa punctata*. During the parasitological investigation total of 250 fishes were examined, out of which 100 were found infected. Fishes were collected from various water bodies of Meerut region during Nov 2018 to Oct 2019. Different body organs were carefully examined, cyst was found in the intestine mesentery in its intermediate host. Infection observed in the *Channa punctata* intestine mesentery throughout the year identified as a Plerocercoid Stage ofproteocephalus sp. on the basis of morphological characters. Overall prevalence 27% and intensity 1-56 (mean 4.8) was calculated per infected fish. The results show increased prevalence and mean intensities of infection were noted from March to June and November to December indicating that spring, late autumn and early winter are the main periods of infections. Findings also suggest that the breeding period, feeding habitat and environmental factors influence the seasonality of parasitic infection.

Key words: *Channa punctata, Protecephalus, Proteocephalidae, prevalence, Meerut*

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ASSESSMENT OF VOLUMETRIC SOIL MOISTURE CONTENT FOR UTTARAKHAND, INDIA

Himanshu Chaubey[1*], Aditi Lohumi[1], Ayushi Agarwal[1] and Deepak Kumar[2]

[1]B. Tech Agricultural Engineering, College of Technology, GBPUA&T Pantnagar

[2]Assistant Professor, Deptt. of Soil & Water Conservation Engineering, GBPUA&T, Pantnagar

**Corresponding author email: chaubeyh40@gmail.com*

Measurement of soil moisture content is an important step for providing adequate irrigation to farm lands. Different crops need different level of moisture content for their growth and survival. The amount of moisture present in soil affects the moisture and amount of nutrients available to plants and soil aeration status. Soil water content can be measured on mass or volume basis. The prior information about volumetric soil moisture content (VSMC) is essential for assessing the status of plant available water in soil and for scheduling irrigation events. Soil moisture can be measured on mass as well as volumetric basis. In this study, monthly variations in average soil moisture content between 2018 and 2019, on volumetric basis have been studied for all the thirteen districts of Uttarakhand. The data of water Resources Information System has been used. The data for monthly volumetric soil moisture content (%) till 15cm depth of soil has been considered. The results suggested that on an average the monthly VSMC was higher for districts of Kumaon region (29%) as compared with districts of Garhwal region (24%). On an average for Uttarakhand, in the month of August, VSMC was about 38%, while for May, it was only 18%. Thus, VSMC for monsoon months was double than the summer months. During the study period, Almora and Uttarkashi have highest and lowest VSMC of 33% and 22 % respectively. For Uttarakhand, theaverage VSMC was 27% during the assessment period.

Key words: *Volumetric Soil Moisture content, Uttarakhand, Kumaon, Garhwal*

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ROLE OF REMOTE SENSING AND GIS IN LAND RESOURCE INVENTORY

Chandrakant Chaubey[1*], A.K. Chaubey[2], J.N. Pathak[3], Amit Mishra[4], J.K. Tiwari[5] and Deo Kumar[6]

[2,3]Associate Professor; [4,5&6]Assistant Professor &[1]M.Sc. (Ag) Student, Department of Soil Science and Agricultural Chemistry, Banda University of Agriculture and Technology, Banda, 210001

**Corresponding author email: chandrakantchaubey1997@gmail.com*

Soil and water are important natural resources which are vital for the sustained quality of human life and the base of agricultural development. Efficient use of these natural resources is the main challenge facing agricultural scientists, planners, administrators and farmers to ensure food, water and environmental protection for present and future generations as well. Soil reflects the essence of life. An intimate knowledge of their characteristics, classification, location, extent and distribution, potentialities and problems is a prerequisite for establishing sound planning of land use. Inventory of soil resources offers an insight into the potentialities and limitations of soil for its successful use. Modern tools such as Remote Sensing Satellite, Global Positioning System (GPS) and Geographic Information System (GIS) have provided new dimensions for tracking and controlling soil resources for their efficient use. Particularly remote sensing techniques have significantly reduced our field work, and soil boundaries are more reliably delineated than in conventional methods. Hence, it is a highly proven technology that is effective for mapping and characterizing land resources.

Key words: *Remote Sensing, GPS, GIS, Mapping*

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WATER SCARCITY AND REDUCING WATER LEVEL OF NON GLACIAL PERENNIAL RIVERS

Sourav Dani

GBPUA&T, Pantnagar, Uttarakhand

Water scarcity in the lower Himalayan regions is evident. Global warming has inflicted snowfall pattern and magnitude, which has resulted in a decrement of groundwater recharge and the recharge of the aquifers. Further variability in monsoon has brought a concern for the agricultural practices in In the Shivaliks, basically Uttarakhand. The objective of the paper is to analyze various data on reducing level of water in non-glacial perennial rivers and the role of vegetation, forest fires and sedimentation in the same context. The study area for the analysis was chosen the Naula watershed of Uttarakhand state. The analysis involves the study of morphometric characteristics of the watershed, data on base flow estimation, sedimentation analysis from silt monitoring station of Kedar, Naula and the study of chirpine trees (the abundant vegetation comprising the forests of the region) and their impact on the hydrology and groundwater recharge through evapotranspiration. Since the declining precipitation (snowfall) in the high altitude regions of Shivaliks has resulted to low water yields for the offseason consumption. Yet there is a chance to overcome this scarcity through the native people's initiatives and commitments.

Key words: *The Himalayas, Shivaliks, Naula watershed, Pinus roxburghii, Evapotranspiration, Vegetation, Snowfall, Precipitation, Hydrology, Aquifers, Morphometry*

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IMPACT OF LONG TERM CONSERVATION AGRICULTURE ON VERTICAL DISTRIBUTION OF CARBON POOLS IN CALCAREOUS SOIL

Bishnuprasad Dash[1] and Samanyita Mohanty[1]

[1]Department of Agricultural Chemistry and Soil Science, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, 741252, West Bengal

A study was conducted in long-term conservation agriculture experiment involving various combinations of tillage and residue management practices in a rice-wheat cropping system at South Pangabri plot of Dr. Rajendra Prasad Central Agricultural University, Pusa,Samastipur, Bihar under sub-tropical humid climate. The study was undertaken during Kharif 2016 to Rabi 2016-17 with an objective to understand the effect of conservation agriculture on different pools of carbon in soil. The experiment was laid out in a randomized block design (RBD) with 8 treatments with varying degree of residue retention in rice and wheat. Grain yield in conventional tillage practices [PTR-CTW] in both rice and wheat crop was significantly lower than the zero tillage treatments. Total soil organic carbon (TOC) in 0-5 cm, 5-15 cm and 15-30 cm depth, under zero tillage rice- zero tillage wheat on bed with residue treatment [ZTR-ZTW(B)+R] was significantly higher over conventional tillage [PTR-CTW] treatment. The Walkley and Black carbon (WBC) under treatment ZTR-ZTW+R was 74 % higher over PTR-CTW at 0-5 cm depth. The predominance of different fractions of oxidisable carbon in soil was found in the order: Non-labile > Very labile > Labile > Less labile. The content of TOC, WBC, Microbial biomass carbon (MBC) decreased with increase in soil depth while that of inorganic fraction increased. Conservation agriculture practices with minimum soil disturbance, residue retention and crop diversification improved soil organic carbon status and played a crucial role in improvement of soil quality under calcareous soil conditions.

Key words: *Conservation agriculture, Carbon pools, Tillage, Residue management*

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IMMENSE POTENTIAL OF SUGARCANE IN CARBON SEQUESTRATION FOR ENVIRONMENTAL SECURITY

Kamini Singh, L.S. Gangwar, Brahm Prakash, Anita Sawnani and Om Prakash

ICAR-Indian Institute of Sugarcane Research, Lucknow 226 002
Corresponding author email: kaminipkv@gmail.com

Global warming is causing qualms and uncertainties for all living organism and also for the environment. The cause of global warming is presence of high carbon dioxide in the Earth's atmosphere. When rising concentration of carbon dioxide is present into the atmosphere, it acts like the ceiling of a greenhouse gases, trapping solar energy and retarding the escape of reflected heat. Designing of carbon trading is a highly regular and economic incentive in which it intends to reduce overall emissions of carbon dioxide, along with other greenhouse gases from the atmosphere. The plants play a crucial role in soil carbon sequestration which is a novel practice and implies transferring of atmospheric CO_2 into soil. The advantage of soil carbon sequestration is the security of higher foodstuff, accelerating renewability and diversification. The soil of land is economical sink for carbon dioxide and very profitable for higher yield. Increase amount of carbon stocks in soil would represent a significant GHG mitigation. The C_4 crop like Sugarcane has the potential to sequester considerable amounts of carbon from the atmosphere.

Sugarcane can sequestrate up to 0.66 tonnes of CO_2 per ha per year in plant-stones (microscopic grains of silica in plant leaves, particularly grass-based pastures such as sugarcane and wheat) in comparison with other crops such as legumes sequestrate little or no CO_2. For a sugarcane farmer, the decision of cultivation of sugarcane crop instead of another crop is fruitful because growing of sugarcane crop shows 0.25 tonnes extra of CO_2 per ha per year, being securely sequestered in the soil inside plant-stones. The relatively simple decision to choose to grow one sugarcane variety instead of another can result in an extra 0.25 tonnes of CO_2 per ha per year being securely sequestered in the soil inside plant-stones. This process is termed plant-stone carbon and is also referred to as phytolith occluded carbon. Many research shows that plantstone carbon has been extracting 300 million tonnes of CO_2 per year from the atmosphere and storing it securely in soil for thousands of years. The knowledge of carbon trading systems in farmers has become a source of earning additional income without distracting from existing income streams. But still there are many gaps in our understanding for soil carbon sequestration and we have still to learn more about carbon sequestration such as utilization of land, its management, mechanisms, controlling soil structure and ways to increase the storage time of carbon in the soil.

Key words: *Sugarcane, Global warming, Carbon trading, Carbon sequestration*

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EFFECT OF DIFFERENT CULTIVARS WITH FERTILITY MANAGEMENT THROUGH ORGANIC MANURE ON GROWTH AND YIELD OF WHEAT (*Triticum aestivum* L.)

Sandeep Kumar, Thomas Abraham, Manoj Kumar*, Lipi Rina and Km Nikam Kumari

Department of Agronomy, Naini Agricultural Institute,
Sam Higginbottom University of Agricultural, Technology & Sciences (Formerly Allahabad Agricultural Institute)
*Allahabad - 211007 Uttar Pradesh, India *Corresponding author email: manojagric@gmail.com*

An investigation was carried out during 2015 in sandy loam soil at the certified organic experiment farm of the SHIATS Model of Organic Farm (SMOF) in NAI, Prayagraj (Allahabad), Uttar Pradesh, to study the response of wheat cultivars to different sources of organic nitrogen nutrient on growth and yield of wheat. Experiment consisted of different treatments cultivar *i.e.*, (V_1) PBW 373, (V_2) K 9423 (UnnatHalna) and (V_3) PBW 502 and management of nitrogen *i.e.*, (M_0) Control, (M_1) FYM (15 t ha_{-1}), (M_2) Poultry manure (4 t ha^{-1}), (M_3) Vermicompost (6 t ha^{-1}) and (M_4) Goat manure (5 t ha^{-1}) laid out in split plot design. Based on analysis revealed that, application of treatment combination T_{12} [PBW 502 + Poultry manure (4 t ha^{-1})] resulted in significant and maximum plant height (cm) at 90 DAS, number of tillers $hill^{-1}$ at 60 DAS and harvest index (%) with grain yield. Further, the highest straw yield recorded was treatment T_{11} [PBW 502 + FYM (15 t ha^{-1})].

Significant and maximum growth and grain yield of wheat were recorded treatment combination T_{12} [PBW 502 + Poultry manure (4 t ha^{-1})]. The probable reason might be inherent genetic ability, suitability and adaptability of which have resulted in to higher rate of photosynthesis as well as higher translocation of photosynthates from source to sink and more protein synthesis. Organic manures increase the nutrient holding capacity of soil and minimize the effect of toxicants and also make the soil biologically active as these are good source of food and energy for soil micro-organisms and increase the activity of microbes which bring non-available plant nutrients into available form, thus improving the growth character.

Key words: *Poultry manure, sandy loam, cultivar and manure*

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EFFECT OF PRE AND POST EMERGENT CHEMICAL HERBICIDES AND NON-CHEMICAL WEED MANAGEMENT PRACTICES ON YIELD AND YIELD ATTRIBUTES OF BLACK GRAM OR URD BEAN (*Vigna mungo* L.) UNDER INDO-GANGETIC PLAINS OF INDIA

Sachin Kumar and *Manoj Kumar, Km Nikam Kumari and Sagar Kumar

Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut-250 110, U.P.
**Corresponding author email: manojagric@gmail.com*

A field experiment was conducted during *kharif* season 2011 in sandy loam soil at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (UP), India, to study the effect of weed control treatments on weeds and yield of urdbean (*Vigna mungo* L). The experiment was conducted in Randomized Block Design with four replications comprising eleven treatments of weed management (T_1) weedy check, (T_2) one hand weeding at 20 DAS, (T_3) Two hand weeding at 20 and 40 DAS, (T_4) Quizlofopethyle (5 EC) @ 50 g a.i./ha at 20 DAS PoE, (T_5) Pendimethalin (30 EC) @ 1 kg a.i./ha at PE, (T_6) Sodium Acifluorfen 16.50% + Clodinafop Propargyl 8.00% EC (24.50 EC) (U-dora) @ 172 g a.i./ha at 20 DAS PoE, (T_7) Sodium Acifluorfen 16.50% + Clodinafop Propargyl 8.00% EC (24.50 EC) (U-dora) @ 245 g a.i./ha at 20 DAS PoE, (T_8) Sodium Acifluorfen 16.50% + Clodinafop Propargyl 8.00% EC (24.50 EC) (U-dora) @ 318 g a.i./ha at 20 DAS PoE, (T_9) Sodium Acifluorfen 16.50% + Clodinafop Propargyl 8.00% EC (24.50 EC) (U-dora) @ 172 g a.i./ha at 30 DAS PoE, (T_{10}) Sodium Acifluorfen 16.50% + Clodinafop Propargyl 8.00% EC (24.50 EC) (U-dora) @ 245 g a.i./ha at 30 DAS PoE, (T_{11})Sodium Acifluorfen 16.50% + Clodinafop Propargyl 8.00% EC (24.50 EC) (U-dora) @ 318 g a.i./ha at 30 DAS PoE. The results indicated that chemical methods of weed control significantly reduced the weed population effectively over weedy check. The maximum yield attributes number of pods/plant and1000-grain wt. (g) and significantly the highest grain and straw yield were recorded with the application of (T_{10}) Sodium Acifluorfen 16.50% + Clodinafop Propargyl 8.00% EC (24.50 EC) (U-dora) @ 245 g a.i./ha at 30 DAS PoE and established its superiority over rest of the herbicides. The per cent increase in grains and straw yield was to the tune of 56.52 and 17.94 as compared to weedy check.

Key words: *Blackgram, Herbicides, Pendimethalin*

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EFFECT OF YAMUNA RIVER FLOODING AND EROSION ON CHEMICAL SOIL PROPERTIES OF DIFFERENT VILLAGES OF PRAYAGRAJ DISTRICT, UTTAR PRADESH, INDIA

Manoj Kumar[1*], Ashwani Kumar Singh[2], Praveen Kumar[3], Km Nikam Kumari[4], Sooraj[5] and Ghulam Rabbani[6]

Chaka Block, State Agriculture of Seed Store,
Department of Agriculture, Prayagraj (Allahabad), Uttar Pradesh, 211008
[2]District Agriculture Officer, Department of Agriculture, Prayagraj, Uttar Pradesh, [3]A.T.M Chaka block, Prayagraj, [4,5]B.Tech. Student of Vaugh Institute of Agricultural Engineering and Technology (VIAET), SHUATS, Prayagraj, [6]Technical Assistant, Regional Soil Testing Laboratory, Mundera, Prayagraj
**Corresponding author email: manojagric@gmail.com*

An investigation was carried out during 2019, September atPrayagraj (Allahabad), Uttar Pradesh, flood affected areas of Chaka Block, Krachhana Tehsil. The flood sites study was statistically analysis in

randomized block design with three different replications. Flood affected villages selected for the analysis were: (S_1) Flood erosion site area village Mohabbat Ganj Kachhar, (S_2) Low flood with cultivated area village Mohabbat Ganj Uparhar (Khatoni No. 00236 or Khasra No. 789), (S_3) High flood without cultivated area village ArailKachhar, (S_4) High flood with cultivated area village Mahewa Paschim Patti Kachhar and (S_0) Control (Arable land area village MahewaPurab Patti Uparhar (SHUATS, Crop Research Farm). Results of the investigation revealed that (S_4) High flood with cultivated area village Mahewa Paschim Patti Kachhar is very responsive to the different chemical properties. Treatment high flood with cultivated area village Mahewa Paschim Patti Kachhar observed significant and maximum for organic carbon, nitrogen, phosphorous, potassium, sulfur, boron, iron and zinc and non-significant and maximum electrical conductivity, chlorine and manganese. While higher significant pH was recorded under treatment site Control (Arable land area village MahewaPurab Patti Uparhar (SHUATS Crop Research Farm).

Key word: *Flood, 2019, Yamuna, chemical, erosion*

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IMPACT OF VARIOUS SUGARCANE VARIETIES ON JAGGERY PRODUCTION IN WEST UTTAR PRADESH

Jai Prakash Singh, Sunderpal and Viresh Singh

Department of Agronomy, Sugarcane Research Station, Muzaffarnagar-251001 (UPCSR)

Corresponding author email: jaiprakash7696@gmail.com

Sugarcane is the most important and one of the leading cash crops of the country. Besides sugar, the natural sweetener viz., jaggery and khandsari are being produced from this crop. Jaggery industry is an important rural based cottage industry in the country. Jaggery is a wholesome diet. It contains 0.6-1.0% minerals, iron 1.1%,calcium 0.4-0.8% magnesium and phosphorous (0.045%) and it also contains reducing sugar (glucose and fructose)10-15 %, protein 0.25% and fat 0.10%. In rural areas jaggery is a important part of daily diet for increase human life span. Jaggery is very rich in iron and prevents anemia. The jaggery quantity, quality and taste are influenced by sugarcane variety and environmental factors such as weather, soil health, biotic and abiotic stresses. The cane variety development programme does not consider jaggery quality as a criterion for variety release. Keeping in view an experiment was conducted at sugarcane research station, Muzaffarnagar to find out suitable sugarcane variety for jaggery/ *gur* production in west Uttar Pradesh during spring 2017-18 and 2018-19. The experiment was laid out in randomized block design with nine sugarcane varieties viz.,UP 05125,CoS 08276, CoS 8279, CoS 12232, CoSe 03234, CoSe 11453, Co 0238, Co 05011 and CoS 767 (standard). On the basis of pooled mean, highest jaggery yield (t/ha) was obtained from variety Co 0238 (11.55) followed by CoS 12232 (10.24), CoS 08276 (10.01) and Co 05011 (9.87) CoSe 03234 (9.78), CoS 08279 (9.33) and UP 05125 (8.53) over standard CoS 767 (6.79). With regards to *gur* per cent in cane the sugarcane variety Co 0238 produced higher (12.85) followed by CoSe 03234 (11.80), UP 05125 (11.70), Co S 08276 (11.58) and Co 05011 (11.53) over CoS 767 (10.86). Overall, results indicated that varieties Co 0238, CoSe 03234 and UP 05125 in early and Co S 12232 Co S 8276, Co S 8279 and Co 05011 in mid late group can be recommended for quality jaggery/ *gur* production in western tract of Uttar Pradesh.

Key words: *Sugarcane, Variety, Jaggery yield*

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ASSESSMENT OF SOIL FERTILITY STATUS OF BASTAR, CHHATTISGARH, INDIA

P. Smriti Rao[1], Tarence Thomas[2] and Ashish David[3]

[1]Department of Agriculture, Integral Institute of Agricultural Science and Technology, Integral University, Lucknow, U.P.[2] Department of Soil Science, [3] Department of Soil Water and Land Conservation, Sam Higginbottom Institute of Agriculture, Technology & Sciences- 211007 Allahabad, U.P.

A survey of chemical properties of soil of farmers' fields of 'Bastar' an allied area of Chhattisgarh was carried out in 2018-19. The main objectives of this study was to collect information regarding soil macronutrient status and its relation with various chemical properties of soil. For this 6 sampling points were selected and soil samples were collected at a depth of 0-15 and 15-30 cm and analyzed for Nitrogen (N), phosphorous (P), potassium (K). The N, P, K, ranged from 188.6-276.64, 7.62-10.72, 121-242.5, kg ha^{-1} respectively. By analyzing the soil samples, it was found to be slightly acidic. The nitrogen, phosphorous, potassium values are found to be low in all villages. There is an increasing awareness for the need to pay greater attention towards the role of macronutrient enhancement in the soil for good soil health and proper nutrition of plant so as to attain optimum economic yield.

Key words: *Bastar district, Chemical properties, Physical properties, Soil*

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OPTIMAL PLANNING AND UTILIZATION OF LAND AND WATER RESOURCES OF LALAI DISTRIBUTARY OF LOWER GANGA CANAL COMMAND

Kaushal Shakya, Mohd. Aftab Alam, D.M. Denis, Rajat Mishra, Rohit N Padyar and Swapnil Jain

SHUATS, Prayagraj, Uttar Pradesh, India

It is well known that water and land are the two basic needs of our society. The proper management and planning of these resources are must, particularly in a canal command. Therefore, the present study suggested an optimal cropping pattern for the Lalai distributary command of Kaimganj & Nawabganj block, located in Farrukhabad district of Uttar Pradesh. The study area lies between 24°48'32" to 25°19'0" N latitude and 81°44'38" to 82°19'19" E longitude. This canal network is having 10 minors. The total area of the Lalai distributary Command of Kaimganj & Nawabganj block is 61973 ha. Linear programming software LINGO-17 was used to allocate optimal area under different crop activities, and conjunctive use of surface and groundwater. The weekly gross irrigation demand was estimated using 23 years of climatology data and Penman-Monteith equation as well as effective rainfall. The 23 years average weekly canal discharge, gross irrigation demand and present net discharge from minor irrigation structures were utilized for conjunctive use planning. A total of 20 crops were included in the optimization plan. Six optimal crop plans for the study area were developed on the basis of available canal water, and 50, 60, 70, 80, 90, and 100% of the existing net draft of groundwater through minor irrigation structures. The annual return of Rs. 202.52, 273.04, 343.55, 414.07, 422.87 and 442.87 crore from the proposed crop plans were estimated which were about 0.98, 14.33, 1.67, 2.01, 2.05 and 2.15 times of the net return under existing cropping pattern respectively, The proposed crop plan included Wheat, Mustard, Sugarcane, Gram, Pea, Barley, Sunflower, Masur, Onion, and Potato for Rabi and for Kharif Paddy,

Sorghum, Arhar, Millet, Groundnut, Tobacco, Moong, Til, Maize, and Urad. The study further concluded that with the use of available canal water and groundwater pumpage at the existing rate of its utilization, one can get 60% more profit than the existing cropping pattern. Therefore, replacing the existing cropping pattern in the Bellan Canal Command of Uruwa block by optimal cropping pattern would be profitable to the farmers of the study area up to the permissible limit of groundwater abstraction. The condition would further improve if the availability of canal and groundwater were increased by the improvement of the canal network, increasing irrigation efficiency and having proper artificial groundwater recharge planning.

Key words: *Canal command, Cropping pattern, Groundwater*

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APPLICATION OF REMOTE SENSING AND GIS IN FLOOD RISK ZONATION

Amar Kant Gautam[1]*, Tarun Kumar[2] and Manish Kumar[3]

[1]Dr Rajendra Prasad Central Agricultural University Pusa, Samastipur - 848 125, [2]Krishi Vigyan Kendra, Saraiya, Muzaffarpur- 843126, [3]Krishi Vigyan Kendra, Banka- 813102, Bihar
**Corresponding author email: amarkant.gautam@gmail.com*

Flood is a natural hazard which causes a massive devastation by overflowing of water. An attempt has been made in this study to prepare flood hazard risk zone maps for a part of Gandak river catchment based on multi-criteria assessment using remote sensing and Geographic Information Systems (GIS). Thematic maps (layers) such as rainfall, slope, drainage density, soil type, land-use and population density, which are major influencing factors were prepared. Layers are assigned with ranks and weights according to their relative importance and their corresponding normalized weights were obtained based on Analytic Hierarchy Process. Eventually, the thematic maps were integrated using Arithmetic Overlay process in GIS environment to generate flood hazard risk zones map. The flood hazard risk zones were classified with respect to different hazard impacts i.e. 'very low', 'low', 'moderate' and 'high' of the entire area.

Key words: *Flood risk, Multi-criteria assessment, Analytic Hierarchy Process, Geographic Information Systems (GIS) and Remote Sensing Applications*

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ASSESSMENT OF IMPACT OF DIFFERENT LOW COST FILTER MATERIAL FOR ROOFTOP RAINWATER HARVESTING STRUCTURE

Tarun Kumar[1]*, Anupma Kumari[2], Amar Kant Gautam[3] and Manish Kumar[4]

*[1*2,3] Krishi Vegyan Kendra, Saraiya, Muzaffarpur- 843126, [4] Krishi Vigyan Kendra, Banka, 813102, Bihar*
**Corresponding author email: tkumar.phd2015.geo@nitrr.ac.in*

Groundwater is declining at a very fast rate in the Muzaffarpur district. Water is essential and most importance resource for survival on earth. India have only 2.4% land, 4% water, and 18 % share of ward population. Freshwater is the lifeblood of the biosphere and the backbone of socio-economic development of a country. Day by day increase in the water demands from different sectors such as drinking, industry, agriculture etc.are decreasing the quality and quantity of this important natural resource. In the Muzaffarpur district many village panchayats are facing water crisis due to decreasing of groundwater level. Rooftop Rain Water Harvesting is the technique through which rain water is

captured from the roof catchments and stored in reservoirs. Harvested rain water can be stored in sub-surface ground water reservoir by adopting artificial recharge techniques to meet the household needs through storage in tanks. The main objective was to assess efficiency of low cost Filter material design for Rooftop Rainwater Harvesting Structure. In this technology seven replications were used for designing the filter (T1) Boulder 2 meter: 0.5-meter stone: 0.5 Sand, (T2) Boulder 1.0 meter: 1-meter stone: 0.50 sand fill with bottle: 0.5 Sand, and (T3) Boulder 1.5 meter: 1 meter stone: 0.5 charcoal: 0.5 Sand. Performance of the filter found as low cost and passing the rainwater to groundwater (T2). The study revealed that there was a need to adopt this technique at mass level to get significant results. This would be possible only with the help of people, participation. The possibilities to motivate the people for adoption of the technique at mass level have been reviewed.

Key words: *Filter, Roof top Rainwater Harvesting, Artificial Groundwater Recharge*

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SALT-TOLERANT ZINC SOLUBILIZING MICROORGANISMS: A TOOL TO MITIGATE MALNUTRITION THROUGH BIOFORTIFICATION OF ZINC IN CEREAL CROPS UNDER SALINE CONDITIONS

Priya Mishra and Naveen Kumar Arora*

Department of Environmental Science, Babasaheb Bhimrao Ambedkar University
Vidya Vihar Raebareli Road Lucknow-226025
**Corresponding author email: nkarora.bbau@gmail.com*

Zinc is an essential micronutrient particularly important during the period of rapid growth. In plants, Zn is essential for the transformation of carbohydrates, chlorophyll formation, the growth hormone auxin and enzymatic reactions. Apart from this, it is required as a structural component of a large number of proteins, such as transcription factors and metalloenzymes. According to an estimate 60-70% of the population in Asia and Africa are at high risk of low zinc uptake. Zinc deficiency is directly linked to unavailability of zinc in soil. Saline soils which also contain a high amount of soluble salt, high pH and low electrical conductivity have limited availability of Zn. In such condition agriculture production is severely hampered. It has been also realized that apart from lower yield, crops grown in salt-affected soil are also low in micronutrients. Use of salt-tolerant zinc solubilizing microorganisms (ST-ZSB) may be useful in enhancing the productivity of cereal crops along with increased zinc content. In comparison to genetic manipulation and breeding methods, ST-ZSB provide cost effective and environment-friendly solution for enhancing nutritional status in cereal crops. Therefore, biofortification of staple crop with Zn could provide a sustainable solution for malnutrition.

Key words: *Biofortification, Micronutrients, ST- ZSB, Cereal crops*

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BIOCONTROL PROPERTIES OF FLUORESCENT PSEUDOMONADS FOR ENHANCING YIELD OF TOMATO (*Lycopersicon esculentum*) UNDER SALINE CONDITIONS

Priyanka Verma and Naveen Kumar Arora*

Department of Environmental Science, BabaSaheb Bhimrao Ambedkar University, Lucknow
**Corresponding author email: nkarora.bbau@gmail.com*

Tomato (*Lycopersicon esculentum*) is considered as major source for antioxidants, vitamins and minerals. Lycopene is the major source of antioxidant found in tomato which is most prominent lipophilic unsaturated carotenoid which provides red colour in tomato. According to APEDA, India is second largest producer of tomato with share of 11% next to China which ranks first with share of 28% in the world. In recent years, farmers are continuously using chemical fertilizers and pesticides to protect their crops from phytopathogens. The use of chemical pesticides prove to be very efficient to kill the phytopathogens but they are also very harmful and toxic for the environment. Synthetic pesticides are found to be non-targeted as they not only kill the phytopathogens but also are harmful for beneficial microbes of soil. The bioprospecting of Fluorescent pseudomonads as potential antagonists for pathogen biocontrol, by secondary bioactive metabolites obtained by them, is one of the alternatives currently to be employed for the control of diseases, especially in species of agronomic importance. Fluorescent pseudomonads are involved in the variety of plant growth promoting mechanisms which play very important role in promoting plant growth and biocontrol against pathogens. The various growth promoting mechanisms by Fluorescent pseudomonads are mobilization of soil compounds (phosphorous and metals), the protection of plants under stressful conditions for counteracting the negative impacts of stress, making them available for the plant to be used as nutrients (nitrogen fixation; phosphate solubilization), siderophore production, defense against phytopathogens, reducing plant diseases by producing antibiotics and hydrocyanic acid (HCN), phytohormones (Indole 3-acetic acid, Cytokinin and Gibberellin) production and so on. Biopesticides can be the best option which can take place of harmful chemical pesticides in the agro-ecosystem.

Key words: *Fluorescent pseudomonads, Biocontrol, Tomato, Biopesticides, Lycopene*

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IMPACT OF FRONT LINE DEMONSTRATIONS ON SESAME PRODUCTIVITY AND PROFITABILITY IN FARMER'S FIELD OF SITAPUR DISTRICT OF U.P.

Ambreesh Singh Yadav*

Krishi Vigyan Kendra-II, Sitapur, Uttar Pradesh
Present Address: U.P. Council of Agriculture Research, 8th Floor Kisan Mandi Bhawan, Vibhuti khand Gomti Nagar, Lucknow-226010
**Corresponding author email: ambreeshy7@gmail.com*

Total 59 frontline demonstrations (FLDs) on sesame were conducted in cluster by Krishi Vigyan Kendra-II, Sitapur, Uttar Pradesh during 2012-13 to 2014-15. The critical inputs were identified in existing production technology through farmers meetings and group discussion. The findings in respect of sesame average yield trend of demonstrations ranged from 7.1 to 7.2 q/ha and yield increase ranged from 60 to

65.12 per cent over the farmers' practices yield. The yield levels were considerably lower under farmers' practices because of considerable variation in the extent of adoption of recommended technology depending upon the amount of risk involved in terms of cost, convenience, skill and knowledge about the concerned practice. Average extension gap, technology gap and technology index of sesame were found 2.73 q/ha, 1.87 q/ha and 20.74 per cent. Average net return and benefit cost ratio of demonstration plots in sesame crop were Rs. 17,383 ha^{-1} and 2.25:1 higher than the farmers' practices Rs. 10,403 ha^{-1} and 1.56:1. Variations in the technology gap and index percentage were observed due to variation in agro-climatic parameters, soil fertility, biotic stresses, and socio-economic status and management practices. This variation can be narrowed down by encouraging the farmers to adopt sustainable technological practices for enhancing the production and productivity of sesame crop. The performance of improved technology was found most effective in controlling least number of affected plants m^{-2} as well as least number of pods $plants^{-1}$ with the application of pesticide. The productivity was better over farmers' practices under demonstrations. Hence, sesame production and protection technology have a broad scope for increasing the area and production of oilseeds at each and every level i.e., district, state and national level.

Key words: *Extension gap, front line demonstration, sesame, technological gap, technological index, yield*

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EFFECT OF INTEGRATED USE OF CHEMICAL FERTILIZERS, FYM AND GREEN MANURES ON SOIL FERTILITY AFTER MAIZE HARVESTING IN MAIZE-WHEAT CROPPING SYSTEM IN A MOLLISOL

Varsha Pandey* and Ajaya Srivastava

Department of Soil Science, College of Agriculture, G.B.P.U.A.&T., Pantnagar, U.S.Nagar, 263145, Uttarakhand
**Corresponding author email: varshapandey.p93@gmail.com*

Imbalanced and excessive use of chemical fertilizers alone has lead to significant degradation of soil health, crop growth and also has long term adverse effects on environmental quality. Therefore, study was conducted at Norman E. Borlaug Crop Research Centre (CRC) of the G.B. Pant University of Agriculture and Technology, Pantnagar, Distt. U.S. Nagar to assess the impact of integrated use of chemical fertilizers, FYM and green manures on soil fertility after maize harvesting in a maize wheat cropping sequence. Results revealed that organic carbon in soil ranged from 0.47 to 0.99 %, available N ranged from 112.90 to 183.98 kg ha^{-1}, available P ranged from 13.45 to 28.94 kg ha^{-1} and available K ranged from 126.56 to 200.85 kg ha^{-1}. It was observed that combined application of organic and inorganic sources of nutrients played an important role in the enhancement of chemical properties of soil. The application of balanced fertilization along with use of FYM and green manures led to better root growth, higher root biomass, direct incorporation of organic matter and more addition of plant residues.Organic carbon is considered as a store house of nutrients and determines the overall health of the soil. Thus, application of organic residues (FYM and green manures) also enhanced the N, P and K status of soil. Thus, it was concluded from the study that integrated nutrient management system with conjunctive use of chemical fertilizers plus organic manures is an alternative cost effective solution for management of soil fertility and ultimately improving soil health.

Key words: *chemical fertilizers, FYM, green manures, maize-wheat system, soil fertility*

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COST ANALYSIS BY PERFORMANCE EVALUATION OF MAIZE GRAINS IN THE MODIFIED STR DRYER

Dinesh Rajak[1]*and Alex Winter-Nelson[2]

[1]Department of Processing and Food Engineering, College of Agricultural Engineering, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, India, [2]University of Illinois at Urbana-Champaign, USA
**Corresponding author email: dineshrajak437@gmail.com*

The main objective of this study was to improve the design of an existing STR crop dryer with a view to improve its drying efficiency, reduce the drying time and produce hygienic and quality dried maize seed economically. Modifications were made on the design of the existing STR dryer by installing a temperature regulation mechanism and a high volumetric capacity centrifugal fan to blow hot air from the heat supply unit to the drying chamber. The dryer consisted of two perforated concentric cylinders with grains inside the annular space. Air was passed from the inner cylinder through walls with bottom and top closed to dry the grains inside the annular space. The initial moisture content was 16.00 (% w b) and after drying the final moisture content (%w b) was 10.51, 10.97 and 11.11%for grains at three locations i.e. inner, middle and outer, respectively. Experiments were conducted on modified STR dryer with 50-60^{0}C drying air for wheat and maize at various levels of initial moisture content. It was observed that the modified STR dryer was able to remove moisture at the rate of 1.28 to 2.00 % (w.b) per hour for Maize crop. The cost for drying 500 kilograms per loading of four different grains was found to be Rs 80.18, the rate being Rs 0.16 per kg.

Key words: *Performance, Dryer, Drying rate, Moisture, Germination, Cost analysis*

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IMPORTANCE OF FOREST RESOURCE MANAGEMENT IN INDIA

Alok Kumar Pandey*, S.R. Mishra, Siddhant Gupta and Arun Kumar

[1]Department of Agricultural Meteorology ANDUAT Kumarganj Ayodhya
**Corresponding author email: alokp7712@gmail.com*

A forest is a natural, self-sustaining community characterized by vertical struc-ture created by presence of trees. Trees are large, generally single-stemmed, woody plants. Forest can exist in many different regions under a wide range of conditions, but all true forests share these physical characteristics. In India, forests form 23 percent of the total land area. Forests provide an array of benefits to human societies above and beyond their pivotal roles as habitat and environmental regulators in natural ecosystems. Forests are main source of many commercial products such as wood, timber, pulpwood etc. About 1.5 billion people depend upon fuel wood as an energy source. Timber obtained from the forest can be used to make plywood, board, doors and windows, furniture, and agriculture implements and sports goods. Timber is also a raw material for preparation of paper, rayon and film. Forest can provide food, fiber, edible oils and drugs. Forest lands are also used for agriculture and grazing. The forest ecosystem contains hundreds to thousands of species with diverse richness, population structure, distributed patterns, and life cycle. There are three major components of the food chain in an ecosystem—producer, consumer, and decomposer; the food chain reveals one of the interactions amongst organisms. Forest resource management should consider not only the components of an ecosystem, but also the ecosystem processes. Management of forest resources is a major problem area in developing countries like India. It is an integration of forest ecology and biology, forest measurements, forest policy and

administration, and courses to predict and evaluate the effects of manipulation. Many tools like GIS and photogrammetric modelling have been developed to improve forest inventory and management planning.

Key words: *Agriculture, Forest eco-systems, Environment, Food, Fiber, Food chain, Forest policy, GIS and Photogrammetric modelling*

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APPLICATIONS OF REMOTE SENSING IN AGRICULTURE

Alok Kumar Pandey*, A.N. Mishra, Siddhant Gupta, Rakesh Kumar Kushwaha

[1]*Department of Agricultural Meteorology, ANDUAT, Kumarganj, Ayodhya*
**Corresponding author email: alokp7712@gmail.com*

Agriculture provides humanity with food, fibers, fuel, and raw materials that are paramount for human livelihood. Remote sensing is the art and science of obtaining information from a distance, i.e. obtaining information about objects or phenomena without being in physical contact with them. Remote sensing is the process of acquiring information about the Earth's surface by measuring its reflected and emitted radiation without coming into direct contact with the object.The remote sensing along with the other advanced techniques such as global positioning systems and geographical information systems are playing a major role in the assessment and management of the agricultural activities.In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. The most useful electromagnetic radiation in remote sensing includes visible light (VIS), near infra-red (NIR) and shortwave infrared (SWIR), to thermal infrared (TIR) and microwave bands. Passive remote sensing sensors record incident radiation reflected or emitted from the objects while active sensors emit their own radiation, which interacts with the target to be investigated and returns to the measuring instrument. Remote sensing has several advantages in the field of agronomical research purpose. The assessment of agricultural crop canopies has provided valuable insights in the agronomic parameters. Remote sensing play a significant role in crop classification, crop monitoring and yield assessment. The use of remote sensing is necessary in the field of agronomical research purpose because they are highly vulnerable to variation in soil, climate and other physico- chemical changes.

Key words: ***Agriculture, Remote sensing, G****lobal positioning systems, Geographical information systems, E****lectromagnetic radiation****, Crop classification, Crop monitoring, Soil, Climate*

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CROP MODELING FOR CLIMATE CHANGE IMPACT AND ADAPTATION

Rahul Sharma, A. N. Mishra, Rakesh Kumar Kushwaha, Alok Kumar Pandey and Siddhant Gupta

Dept. of Agricultural Meteorology, ANDUAT Kumarganj, Ayodhya 224229, UP
**Corresponding author email: rs0100820@gmail.com*

Physiology-based crop simulation models have become a key tool in extrapolating the impact of climate from limited experimental evidence to broader climatic zones, soil type, crop management regimens, and climate change scenarios. While these models are a simplification of the reality, they allow a fair assessment of the complexity of climate impact in agriculture. They are playing an increasingly important role in assisting agriculture to adapt to climate change. Such models help develop new crop

rotations and maximize the value of seasonal climate forecasts. Crop models need to be further improved and tested with climate change scenarios involving various changes in ambient temperature and CO_2 concentration. Current knowledge gaps include limited understanding and modeling of the interactive impact of climate factors, the impact of extreme events (e.g. heat stress, cold stress, frost and excess water) they have facilitated establishment of new hypotheses for climate change, stimulated investigations into climate change adaption.

Key words: *Crop modeling, Temperature, Climate change, Crop physiology, Adaptions*

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EFFECT OF VARIOUS WEATHER PARAMETERS ON THE MOVEMENT OF INSECTS

Rakesh Kumar Kushwaha*, Rahul Sharma and Prince

Dept. of Agricultural Meteorology, ANDUAT Kumarganj, Ayodhya 224229 U.P.
**Corresponding author email: rakesh.pk9695@gmail.com*

The movement and the number of insects are affected by various weather parameters e.g. aphid can not fly in darkness or at temperature less than 13^0C. Their activity increases with increase in temperature up to 29^0C. However, the number of aphids flying depends upon the number that can fly. The development and multiplication of most of the insects is optimum when the temperature ranges from 15 to 35^0C. Extreme temperature condition are harmful for the survival of the insects. Insects may not be able to survive below 1^0C and 50^0C. The relative humidity ranging from 50 to 90% highly favourable for most of the insects higher range of relative humidity combined with moderately low range of temperature is highly favourable for the development and multiplication of the insect. Irrigated fields can have higher relative humidity, which can increase the incidence of insects above the ground. However, soil borne pests can be controlled by keeping the soil saturated or wet for a long time. Locust, a pest of the desert can move from one place to another place in the same direction in which the wind is blowing.

Key words: *Temperature, humidity, wind, insects*

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WEED MANAGEMENT STRATEGIES FOR DIRECT SEEDED RICE IN INDIA

Brijesh Kumar Chaudhary[1]*, Vivek Kumar[2] and Anurag Kumar Singh[1]

[1]Department of Agronomy, [2]Department of Plant Physiology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221005
**Corresponding author email: brijeshk.chaudhary3@bhu.ac.in*

Rice (*Oryza sativa* L.) is the most important human food crop of the world. It Account for more than half of the world population, and more than 90% of rice worldwide is grown and consumed in Asia.Direct-seeded culture has become increasingly important in rice cultivation due to scarcity of rural labour and higher water requirement and production costs of transplanted rice. Direct-seeded rice (DSR) can address the resource-conserving techniques like zero tillage and bed planting requires lesser amount of water and labour force than conventional transplanting. Direct-seeded rice needs only 34% of the total labour requirement and saves 27% of the total cost of the transplanted crop. Here, direct-seeded rice is a cheaper alternative to transplanting to overcome these high input resources required but, heavy infestation of weeds is one of the major constrains for its successful cultivation. So, we need a comprehensive weed

management practices for significant control of weeds and enhance the other input resources to the main plants. In order to achieve the long term and sustainable management of weeds in DSR an integration of different weed management strategies like integrated weed management (IWM) are essential. In IWM, all cultural, mechanical, biological, chemical as well as biotechnological measures are applied for significant weed control.

Key words: *Direct-seeded rice, transplanted rice, weeds management, integrated weed management*

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SUSTAINABLE RATOON CANE PRODUCTION WITH NATURAL RESOURCES AND INTER CROPPING OF GINGER

S.C. Singh[1]*, Shri Prakash Yadav[2], Shravan Yadav[3] and A.K. Singh[4]

[1]Senior Scientific officer (Agronomy), [2]Scientific officer (Agronomy), [3]Agriculture Supervisor (Agronomy), [4]Farm Management Officer, UPCouncil of Sugarcane Research, Shahjahanpur - 242001 (UP)*

**Corresponding author email: subhash upcsr11@gmail.com*

Indiscriminate use of chemical fertilizers and pesticides adversely affect the quality of natural resources (soil and water) as well as health of living beings. Keeping these in view an experiment was conducted during 2015-16 in spring season (plantcane) and their consecutive ratoons upto 2019-20 (four ratoons) at the research farm of Sugarcane Research Institute, Shahjahanpur to study the effect of spacing and natural farming on yield, soil health and economics of ratoon cane. The experiment was laid out in randomized block design with three replications. Experimental sugarcane crop was planted with variety CoS 08279 at different spacing as per treatment. During 2018-19 in third ratoon cane ginger was sown between alternate cane rows. In year 2019-20 with fourth ratoon ginger was grown between alternate cane rows in which ginger was not sown during previous third ratoon cane. Trash mulching was done between alternate cane rows in which ginger was not sown during both years. Mean data of two years (2018-19 and 2019-20) revealed that significantly higher ratoon cane and ginger yield were recorded in 120 cm row spacing with natural resources than that of other treatments. Maximum benefit cost ratio was obtained in third and fourth ratoon cane with 120 cm row spacing and intercropping of ginger along with natural resources. Organic matter, available NPK and microbial population were found to be increased with natural resources along with trash mulching and intercropping of ginger in ratoon cane.

Key words: *Ratoon cane, Ginger, Natural resources, Trash mulching, Soil health, Economics*

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BACTERIAL ENDOPHYTES AS A SUSTAINABLE TOOL TO OVERCOME SALINITY STRESS IN CROPS

Ankita Bhattacharya and Naveen Kumar Arora*

Department of Environmental Science, BabasahebBhimraoAmbedkar University, VidyaVihar, Raebareli Road, Lucknow-226025

**Corresponding author email: nkarora.bbau@gmail.com*

Food scarcity is becoming one of the most serious matter of concern now a days as the world population is increasing day by day. Climate change leads to development of various abiotic and biotic stresses and among them salinity is becoming one of the greatest threat to world's agricultural sustainability in the 21st century. Salinity is one of the most serious problems in arid and semi-arid regions in India.

Salinity is also caused by improper practices of irrigation water logging and sea water intrusion. This causes an urgent need to use some sustainable approach to help plants to overcome such stresses. Among various techniques for enhancing salinity tolerance in plants like genetic engineering, plant breeding technologies and other physical and chemical treatments to soils, incorporating plants with plant growth promoting bacteria is proved to be cost effective and ecofriendly way, additionally these microbes help by triggering some direct and indirect mechanisms. Direct mechanisms include nutrient uptake, phosphate solubilization, various phyto-hormone, osmolites and enzyme production and indirect mechanisms include production of secondary metabolites like antibiotics, hydrogen cyanide (HCN) etc. for inhibition of pathogens to help plant's overall growth performance. Literature shows a lot of work has been done with plant growth promoting rhizobacteria but very less knowledge is available for plant growth promoting endophytic bacteria (PGPEB) in combating salinity stress. PGPEB work in a very similar way as rhizospheric population of bacteria but being in the closer proximity to plant's tissues they in some case may prove to be better option than rhizospheric bacteria.

Key words: *Bacterial endophytes, Plant growth promoting endophytic bacteria, Salinity*

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SEDIMENT FORECASTING USING ARTIFICIAL NEURAL NETWORK (ANN) AND ADAPTIVE NEURO FUZZY INFERENCE SYSTEM (ANFIS)

Ashish Kumar*, Vinod Kumar Tripathi and Kanhu Charan Panda

Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India
**Corresponding author email: ashish48179@gmail.com, tripathiwtcer@gmail.com*

With the continued population growth, it has become crucial to maintain the fertility of the soil up to optimum marks to overcome the scarcity problem of food grains required to feed the population. Erosion is the very intensive phenomenon responsible for soil degradation like removal of top fertile soil. In line with these requirements this study has been carried out to predict the sediment load in the river system by considering one gauging station namely Pachegaon of Godavari basin. Daily rainfall, runoff and sediment data during monsoon period of 26 years (1990-2015) were explored using ArtificialNeural Network (ANN) and Adaptive Neuro Fuzzy Inference System (ANFIS) to forecast the sediment outflow. Statistical indices such as correlation coefficient (r) root mean square error (RMSE), coefficient of efficiency (CE) were used to evaluate the model performances. After comparing the qualified results of different ANN and ANFIS models it was found that ANN model (6-11-1) with single hidden layer, sigmoid activation function and Levenberg-Marquart algorithm performed better than other single and double hidden layered ANN models and ANFIS model with membership function (Triangular, 3) performed well than other ANFIS based models for sediment predictions. With a view to go for better model of these two, comparison has been made between selected ANN and ANFIS based models and it was concluded that ANFIS model with Triangular membership function has better capability to forecast sediment flow for the selected site. Implication of this study may be useful during planning, designing and construction of water harvesting structures and erosion control structures.

Key words: *Artificial neural network, Adaptive Neuro Fuzzy Inference System, Sediment, Triangular and Gaussian Membership Functions, Sigmoid Activation Function*

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EFFECT OF CLIMATE CHANGE ON INSECT- PESTS AND DISEASES

Akhilesh Kumar Prajapati[1*], Alok Kumar Pandey[2] and Krishna Murari[3]

[1]Department of Agronomy, [2]Dept. of Agricultural Meteorology, [3]SMS Agro-met, KVK Chandauli, ANDUAT, Ayodhya

**Corresponding author email:prajapatiakhilesh891@gmail.com*

Effect of climate change on agriculture or more precisely on insect- pests and diseases of agricultural crops is multidimensional. Insect habitats and survival strategies are strongly dependent on patterns of climate. Therefore, it is highly expected that, the major drivers of climate change i.e. elevated CO_2, increased temperature and depleted soil moisture can impact population dynamics of insect-pests and the extent of crop losses, significantly. Global warming will also reduce the effectiveness of host plant resistance, transgenic plants, natural enemies, bio pesticides, and synthetic chemicals for pest management. Anthropogenic CO_2 is almost twice more important for temperature increase than other long-lived greenhouse gases combined. Although increased CO_2 should not directly deleteriously affect insects, the temperature increases driven by the increase in anthropogenic CO_2 already affect insects in profound ways including their distribution, nutrition, phenology and role as disease vectors. Fungal pathogens of insects are favoured by high humidity and their incidence would be increased by climate changes that lengthen periods of high humidity and reduced by those that result in drier conditions. Some insects are sensitive to precipitation and are killed or removed from crops by heavy rains. The increase in temperatures will be more at night than during daytime. Higher nocturnal temperature will reduce the duration of Leaf-Wetness and result in lesser disease incidence.

Key words: *Weather, Rainfall, Temperature, Climate change, Disease incidence*

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WEATHER BASED AGRO-ADVISORY SERVICES FOR ENHANCING CROP PRODUCTION AND FARMERS' INCOME IN WESTERN UTTAR PRADESH

U.P. Shahi*, Shweta Singh, Smita Gupta, Anand Singh and Ashok Kumar

Sardar Vallbhbhai Patel University of Agriculture & Technology Meerut-250110

**Corresponding author email: upshahi@gmail.com*

The agricultural crop production mainly depends on various components like, suitable variety, application of fertilizers, insect and disease infestation, besides these weather parameters also influence the success or failure of agriculture crop production. Weather manifests its influence on agricultural operations and farm production through its effects on soil and plant growth. Out of the total annual crop losses, a sizeable portion occurs because of abnormal weather. The loss could be minimized by making adjustment with coming weather through timely and accurate weather forecasting. Agricultural operations can be advanced or delayed with the help of advanced weather forecast from three to ten days. Recent studies in India showed that economic impact of an Agro-Advisory Service (AAS) based on weather forecasting is significant and benefited the AAS farmers to a large extent through weather-tuned farming. AAS farmers produced more yield when compared to non-AAS farmers owing to technical guidance on all cultivation aspects, especially selection of varieties, timely application of fertilizer/ pesticides, input saving in terms of water, manpower, electricity, and fuel through proper irrigation scheduling. A study was conducted to assess the economic impact of Agro Advisory Service disseminated to farmers in western UttarPradesh. Agrometeorological field Unit (AMFU) Modipuram, Meerut is disseminating weather forecast and advisory for 20 districts of western UttarPradesh since 2009. At

present about 25 lakh farmers are getting the service through SMS. From the study it was found that farmers who have responded the agro-advisory for rice in kharif and wheat, mustard and gram for rabi crop were able to reduce input cost by 2.5 to 4.5% and increase the productivity by 2.5 to 4.4 % as a result net profit increased by 7.6 to 10 % in gram, rice, wheat and mustard, respectively in comparison to the farmers who did not respond to advisory services. Maximum reduction in cost of production was noticed in gram (4.4%) followed by mustard (3.15%) and wheat (2.75%). Similarly highest increase in net profit was recorded in rice (10 %) followed by gram (9.2%), mustard (7.7%) while minimum net profit was found in wheat (7.6 %).AAS responsive farmers earned maximum net profit of Rs 3199 by adopting AAS advisory services in case of rice while minimum in case of Mustard (Rs 2227) in comparison to non - responsive farmers.

Key words: *Agro-advisory, Weather forecast, Farmers income, GKMS*

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DETERMINATION OF SUITABLE EXTRACTANT AND RISK ASSESSMENT OF ARSENIC IN RICE

Jajati Mandal[*1], Akanksha Raj[1], Debasis Golui[2], Preety Bala Kumari[1] and Pritam Ganguly[1]

[1]Department of Soil Science and Agricultural Chemistry, Bihar Agricultural University, Sabour-813210 , [2]Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi 110012, India

[*]Corresponding author email: jajati.bckv@gmail.com

A study was conducted to assess the suitability of the extractants for determination of soil available Arsenic (As) and risk assessment by solubility Free Ion Activity Model (FIAM) under rice (variety: Sushk Samrat). Soil in bulk was collected from six locations of Indo-Gangetic Plain of Bihar, India, varying in physico-chemical properties to conduct the pot experiment using five doses of As 0, 10, 20, 40 and 80 mg kg^{-1}. Six extractants namely 0.2(M) NH_4-Oxalate, 0.05 (N) HCl+0.025 (N) H_2SO_4, 0.5 (M) KH_2PO_4, 0.5 (N) NH_4F, 0.5 (M) $NaHCO_3$ and 0.5 (M) EDTA were used. The results revealed that 0.5 (M) KH_2PO_4 gave the best correlation with the soil properties and crop uptake and hence proved to be the suitable extractant. Regardless of the As dose and the soil type used, in rice tissue, As concentration followed the order root > straw > leaf and grain. The predictability of solubility FIAM in terms of Hazard Quotient (HQ) revealed that 94% variation of As content in rice grain can be explained when 0.5 (M) KH_2PO_4 is being used as an extractant for determination of soil available As. Available arsenic cannot be determined by Atomic Absorption Spectrophotometer (AAS) coupled with Vapour Generation Accessory (VGA) when 0.5 (M) EDTA was used as an extractant.

Key words: *Extractant, Correlation studies, Arsenic, Hazard Quotient, Free Ion Activity Model*

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LARGE CARDAMOM BASED AGROFORESTRY SYSTEM FOR LIVELIHOOD SECURITY: SIKKIM PERSPECTIVE

Santosh K. Chettri, Aseesh Pandey, Kailash S. Gaira and Rajesh Joshi

G. B. Pant National Institute of Himalayan Environment (NIHE)
Sikkim Regional Centre, Pangthang, Gangtok, Sikkim- 737101

Sikkim is the leading producer of large cardamom in India, constituting 84% of the total productions of the country, which is cultivated in agroforestry system. Realizing the potentiality of the crop in improving the rural livelihood and economy, an attempt has been made to understand the ongoing transitions across large cardamom farming patterns and the likely impacts on its contribution to economy at various levels. Besides, large cardamom based agroforestry system, its uniqueness have also been presented in

this chapter. Additionally, diversity of large cardamom endemic to the region, present status, production trends of declining phase, problems and issues highlighting changing socio-cultural scenario and *chirkey/ foorkey* diseases, and future opportunities under large cardamom farming have been discussed. This information base would be useful in understanding the potentiality of large cardamom in improving the economy of rural farmers for long term livelihood sustainability in the region.

Key words: *Agroforestry, large cardamom, production, variety, value addition, packaging*

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PGPRS FROM HIGH ALTITUDE REGIONS OF TEHRI GARHWAL, UTTARAKHAND, INDIA

Abhishek Mathur[1]*, Akshma Koul[1], Juhi Hattewar[1] and Rashmi Jain[2]

[1]Executive Director, R&D Dept., NCS Green Earth Pvt. Ltd., Nagpur, Maharashtra, India; [2]Uttarakhand Technical University, Dehradun, Uttarakhand, India

The continuous usage of agrochemicals and conventional chemical pesticides are strictly influencing the soil health and making the imbalances in the soil nutritional levels. In today's times, different techniques and solutions are readily available provided by different industries and allied researchers for farmers for organic farming. The use of microbes and consortia in the form of Plant Growth Promoting Rhizobacteria (PGPR) detoxifies the soil intoxicated with chemicals and pesticides and also enables the sustainable growth of crops. These microbes play an important role in maintaining soil fertility and plant health. They can act as biofertilizers and increase the resistance to biotic and abiotic stresses. PGPRs are effective growth modulators for the crop as they secrete novel metabolites and growth molecules that enable the crop to sustain in adverse and stress conditions. These molecules also induce systemic resistance and anti- pathogenic effect against the soil borne infections. These beneficial microbes are thus referred as PGPMs (plant growth promoting microbes) and precisely PGPRs (plant growth promoting rhizobacteria). In the present study, total of 25 soil samples from rhizospheric region of different crop fields were collected from different districts of Chamoli and Pauri Garhwal regions of Uttarakhand. The results revealed the isolation of total 56 microbial isolates, out of which 07 strains were found to have PGPR positive traits viz. *Bacillus subtilis*, *Pseudomonas fluorescens*, *Bacillus mycoides*, *Streptomyces* sp., *Vesicular arbuscular mycorrhiza* (VAM), *Serratia marcescens* and *Rhizobium* sp. These isolates were further processed for root colonization and shoot elongation activity.

Key words: *PGPRs, Plant growth promotion, Soil detoxification, Fermentation conditions, Chamoli and Pauri Garhwal regions, Uttarakhand*

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USE OF *Bacopa monnieri* AS AN EFFECTIVE ANTI-DIABETIC AGENT

Rupal Parashar* and Abhishek Mathur#

**Himalayan University, Arunachal Pradesh, India*

#NCS Green Earth Pvt. Ltd., Nagpur, Maharashtra, India

**Corresponding author email: monas9150@gmail.com; abhishekmthr@gmail.com*

Medicinal plants are rich in antioxidants, which make them excellent sources for increased health benefits. Health advantages of diets rich in antioxidant plant compounds include lowering the risk of cardiovascular disease, certain cancers and the natural degeneration of the body associated with the aging process. In the present study, different solvent extracts of whole plant, *Bacopa monnieri* were prepared on the basis of increasing polarity viz. petroleum ether, hexane, methanol and distilled water. The solvent extracts were screened for anti-diabetic activities at 200 mg/ml. The crude extracts prepared in different solvent extracts of the plant were administered in alloxan induced diabetic rats. The separate

groups were prepared as per the samples (solvent extracts crude) to be tested in different alloxan induced diabetic rats models. The control group was administered with Glyburide (GLB) at 10 mg/kg of animal body weight. The results showed that, blood glucose levels get significantly decreased in methanol extract treated mice models in comparison to aqueous extract followed by hexane extracts. No activity was observed in petroleum ether extracts. The results were found significant at 4^{th}, 7^{th}, 14^{th} and 21^{st} day of treatment. The studies showed the effective reduction of glucose levels in methanol crude extract treated diabetic animal model groups in comparison to GLB treated groups. The level of significance was found to be $p<0.05$.

Key words: *Bacopa monnieri, Solvent extracts, Polar and non-polar extract, Anti-diabetic activity, Alloxan induced animal model*

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ANTIFUNGAL POTENTIAL OF CURCUMIN- CHITOSAN FUSED NANOPARTICLES AGAINST PHYTO-PATHOGENS

Akshma Koul*, Juhi Hattewar and Abhishek Mathur

NCS Green Earth Pvt. Ltd., Nagpur, Maharashtra, India

Chitosan and Curcumin, both novel molecules are of great value in today's era. These molecules are having significant antibacterial, antifungal, antiviral, insecticidal properties. Moreover, these molecules are natural, biodegradable, and biocompatible and thus can be easily utilized in novel formulations related to medicine, health and agriculture. Chitosan is nowadays used as a significant agent in micro and nano-capsulations and in drug delivery. These molecules are of great interest for nano-medicine, biomedical engineering and development of new therapeutic drug release systems with improved bioavailability, increased specificity and sensitivity, and reduced pharmacological toxicity. The present study was performed in order to prepare the nano-formulations of chitosan blended with curcumin. The chitosan was extracted and purified from exoskeleton of fresh water crustaceans while curcumin was extracted via solvent extraction method from fresh rhizomes of *Curcuma longa* (Haldi). These nano-formulations were further screened to evaluate the phyto-pathogenic (antifungal) potential against *Colletotrichum gloeosporioides, Phytophthora, Sclerotina sclerotiorum* and *Fusarium oxysporum*. The results showed a remarkable and significant antifungal potential against the pathogens studied as determined in triplicates. The results were observed *in vitro* against the mentioned cultures by the modified method of well puncture method and radial axis inhibition of the respective mycelium. The studies will be replicated on crops having fungal attack in order to validate the studies.

Key words: *Curcumin- chitosan nanoparticles, Phyto-pathogenic potential, Fungal growth inhibition*

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PESTICIDAL POTENTIAL OF COPPER- CHITOSAN FUSED NANOPARTICLES AGAINST INSECTS AND PESTS

Juhi Hattewar*, Akshma Koul and Abhishek Mathur

NCS Green Earth Pvt. Ltd., Nagpur, Maharashtra, India

Chitosan, a natural molecule, is one of the derivatives of chitin extracted and purified from fresh water crustaceans. Chitosan is a wonder molecule having versatile significant activities in health care, medicine and agriculture. Copper is significant antimicrobial agent used as fungicide in agriculture. Chitosan was prepared from chitin extracted from exoskeleton of fresh water crustaceans. The study was performed in order to fuse Chitosan and Copper for formation of Copper- Chitosan fused nanoparticles. The nano-formulation was evaluated in different doses (0.5 ml/l to 2.5 ml/l) for insecticidal

and pesticidal properties on brinjal and okra crops. The results of the study showed significant insecticidal and pesticidal properties on both the crops after 3 days of dosing in comparison to non-treated crops. The results were found to be effective at 1.5 ml/l and 2.5 ml/l but no activity was found at 0.5 ml/l and 1.0 ml/l. The results were found significant in triplicates. Further studies are in progress to optimize the process of nano-particles production and application studies.

Key words: *Copper- Chitosan nanoparticles, Insecticidal, Pesticidal properties, Fresh water crustaceans*

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IMPACT OF CONTRASTING TILLAGE ON N MINERALIZATION UNDER RICE AND MAIZE BASED CROPPING SYSTEMS

Shweta Shambhavi, Rakesh Kumar, Rakhi Kumari, Priti Kumari and Bipin Bihari*

Dept. of Soil Science and Agricultural Chemistry, BAU, Sabour
**Corresponding author email: bipin.agri@gmail.com*

The influence of contrasting tillage and cropping systems on nutrient cycling processes in soil have substantial implications for environmentally sound practices regarding their use. Anattempt had been made to study the effect of different tillage and crop rotation practices andsoil environment (soil moisture and temperature) on dynamics as well as the net amounts ofN mineralized. For this purpose, soils were collected from the field trial laid in split plotdesign with three replications having three tillage systems as main plot and cropping systemsas sub-plots. The soil samples were collected at 0, 10, 20, 30 and 40 days after fertilization ofthe crop. An incubation study was conducted simultaneously to study the effect oftemperature and moisture on net N mineralization. The results revealed that potentiallymineralizable N (No) was around 40 and 50 mg/kg of soil under maize and rice basedcropping systems, respectively. The mineralized N (Nm) was found to be lowest at 0 daysafter fertilization and highest at 10 days after fertilization. In both the cropping systems, rateof N mineralization (kN) was found to be minimum under zero tillage while maximum underconventional tillage system. With regards to cropping system, lowest rate of N mineralizationwas found under rice-lentil (5.32 mg N/kg/day) and maize-maize (5.51 mg N/kg/day). Lowerrate of N mineralization depicts availability of mineral N for a longer period of time.Incubation study carried out at 25 and 35^{0}C and 20 and 40 per cent moisture (v/v) revealedthat at constant temperature with increase in moisture there was decrease in rate of Nmineralization.

Key words: *Crop rotation, N mineralization, Soil moisture, Tillage*

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RAINWATER HARVESTING AND GROUNDWATER RECHARGE

Bhawna Gupta

Department of Agricultural Engineering, College of Technology,Govind Ballabh Pant University of Agriculture and Technology, Pantnagar-263145,India

Water is the basic need of all living beings. We need water for all our activities in day-to-day life. Water supply in the urban area is always a shortage against the total demand. Dependence on groundwater is increasing day by day since the quality and quantity of surface water is decreasing. Water scarcity is a serious problem throughout the world for both urban & rural communities. Infiltration of rainwater into the subsoil has decreased drastically due to rapid urbanization, industrial development & an increase in agricultural field & production. The need to bridge the gap between demand and supply is required. Rainwater, which is the purest form of water, would be an immediate source to

augment the existing water supply by catching water and thereby storing or recharging groundwater wherever it falls. Thirty years back, the areas around our homes and offices used to be unpaved and the rain falling on these areas would percolate into the soil. This water recharged groundwater or remain there for being drawn through shallow open wells. With the proliferation of flat complexes, not only have these areas been avid and percolation of rainwater into the soil almost totally stopped, the quantity of water drawn from the soil below has increased manifold. Consequently, open wells and not-so-deep bore wells started drying up. No sincere attempt has been made for the replenishment of the groundwater table. Rainwater Harvesting is the process of collecting and storing rainwater in a scientific and controlled manner for future use. Rainwater Harvesting in urban areas includes rooftop rainwater harvesting, rainwater harvesting in paved and un-paved areas (open fields, parks, pavement landscapes, etc.).The stored water can be used for domestic and agricultural purposes.This practice is by far the best possible way to conserve water at small as well as large level with the minimum capital requirement. This method is useful in areas where water is scarce. During monsoon majority of the rainfall coming down flows through gutters and gets wasted. Also, the water on the surface is unable to seep into the ground due to the formation of buildings, pavements, roads, etc. Groundwater recharge is the enhancement of natural groundwater supplies using man-made conveyances such as infiltration basins, trenches, dams, or injection wells. Aquifer storage and recovery (ASR) is a specific type of groundwater recharge practiced with the purpose of both augmenting groundwater resources and recovering the water in the future for various uses. The reduction of groundwater table level and drying up of bored wells has rendered us to dig deeper and deeper. This further lowers the GWT and in some areas, this leads to a higher concentration of hazardous chemicals such as fluorides, nitrates, and arsenic. In coastal areas, overexploitation of GW results in seawater intrusion thereby rendering GW bodies' saline. The solution to all these problems is to replenish GW bodies with rainwater by manmade means. Rainwater harvesting at a large level like ponds, lakes, etc. may help in the replenishment of groundwater to a certain level.

Key words: *Rainwater harvesting, rooftop, groundwater, aquifer storage and recovery*

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IMPACT OF NITROGEN SOURCES ON PERFORMANCE OF HYBRID RICE-WHEAT CROPPING SYSTEM IN CALCAREOUS SOIL

Shiveshwar Pratap Singh[1*], S. Jha[1]and S. Dutta[2]

[1]Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar (India) 848125, [2]African Plant Nutrition Institute, Morocco

[*]Corresponding author email: sp26814@gmail.com

The carriers or the sources of added nitrogenous fertilizers play an important role in regulating N transformations, changing N loss patterns and influencing NUE. Thus, there is ample opportunity to improve yields of hybrid rice-wheat system through the use of right nitrogen carriers. Nutrient Expert (NE), a new freely accessible nutrient decision support system based on principles of site specific nutrient management (SSNM), offers solutions for providing field specific fertilizer recommendations to improve yield and economics of rice-wheat growing farmers in the region. Recently some N carriers has been introduced in the market like neem-coated urea, calcium nitrate etc. Thus, for improvement in efficiency of Nutrient Expert recommendations based on locally available N carriers by the farmers, a field experiment was initiated during *kharif*-2016 in hybrid rice-wheat cropping system at experimental farm of RPCAU, Pusa with nine treatment combinations in RBD. The soil of the experimental site was alkaline in reaction, normal in salinity, medium in organic carbon content and deficient in available N, P and K. During *rabi* 2016-17, the grain yield of wheat (HD-2733) varied from 1.63 to 4.43 t/ha under unfertilized and S-

coated prilled urea (S-PU) plot, respectively. The wheat grain yield increased significantly in the entire treated plot with different N carriers over control and N omitted plot. The application of N through S-coated prilled urea (S-PU) showed significant increase in rice equivalent yield (REY) than at control, N omitted and ammonium sulphate plots. Application of neem-coated urea improves the agronomic efficiency of N (AEN) over prilled urea. But further coating of S on neem-coated urea (S-NCU) decreased the AEN. Also, application of N through ammonium sulphate (AS) did not perform better in the system. Thus, among different N carriers, S-PU was the best source followed by calcium nitrate, neem-coated urea, prilled urea, DAP, AS and S-NCU.

Key words: *Urea, neem coated urea, SSNM*

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INTEGRATED NUTRIENT MANAGEMENT: A SMART WAY TO IMPROVE THE SOIL PHYSICAL AND BIO-CHEMICAL PROPERTIES AND PRODUCTIVITY OF SUGARCANE

Manjul Kumar, Arun Alfred David and Amreen Hasan

Department of Soil Science and Agricultural Chemistry, Sam HigginbottomUniversity of Agriculture, Technology and Sciences, Prayagraj 211 007 (UP)

Sugarcane is an important crop of India, is an important agricultural commercial cash crop and grown on 4.5 percent of the net cropped area of country. During 2018-19 it was estimated to have a record production of 400.37 million tonnes. Owing to continuous mono-cropping and heavy feeding nature of the crop the yields have started declining. As it is a long duration crop, complementary and supplementary application of bio-fertilizers along with inorganic sources of nutrients for steady supply of nutrients at different stages of the crop growth over fairly long period is the need of the hour. Integrated nutrient management sustains soil fertility and provides a sound basis for crop production and improves the quality of produce. Organic sources not only supply nutrients, at lower concentrations, but also bring about physical, chemical and biological properties of soil in a positive mode and thereby bringing in a semblance of stability as far as sugarcane yields are concerned. The profound influence on quality parameters by organic sources of nutrients cannot be overlooked. Balanced use of organic, inorganic and bio-fertilizers is essential to maintain a good soil physical and chemical environment and also serve as energy source for the soil microbial biomass. It enhances the productivity of sugarcane by 10 to 15 percent and an impressive improvement in net return and B:C ratio. The paper discusses these issues with respect to integrated nutrient management based sugarcane production system in Indian conditions.

Key words: *INM, Bio-fertilizers, Soil fertility, Sugarcane*

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EVALUATION OF EFFECT OF RAINFALL ON GROUNDWATER TABLE IN DEHRADUN DISTRICT

Vedant Nagpal, Harsh Routhan and Subodh Khanduri

College of Technonoloy, GBPU&T, Pantnagar Uttarakhand

Determination of Groundwater Table level is an important factor in understanding the geological properties of a particular region and helps in the assessment of the water requirements of various sectors like irrigation, domestic and industries. Calculation of groundwater level is done by measuring the reading

of observation wells at different time intervals in the region. In this study, quarterly variations in groundwater level both prior and post-monsoon season, i.e. June, July, August, have been assessed during the years 2014-2019 in Dehradun district of Uttarakhand state with the help of the data obtained from different government departments. The data suggests that the average rainfall of monsoon season during the study period is found out to be 884.04mm which increased the Groundwater level by an average of 2.41m bringing about a 36% increment in the Water table of Dehradun. The results imply that the greatest rise in water table was experienced in the year 2019 of about 5.85m resulting in a 82.51% change in the level corresponding to a heavy rainfall of 1080.5mm in the season, however, the lowest rise or rather decrement in groundwater Level was experienced in the year 2015 with a decrease in water level of about 3.85m falling for about 22.47% corresponding to a considerable amount of rainfall of about 924.67mm still resulting in a drastic fall in the water level.

Key words*:* *Groundwater Table, Dehradun, Rainfall*

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SPRINGSHED MANAGEMENT FOR REJUVENATION OF SPRINGS IN HIMALAYA: INTEGRATING SCIENCE, POLICY, AND PRACTICE FOR WATER SUSTAINABILITY

***Rajesh Joshi and Mayank Joshi**

G.B. Pant National Institute of Himalayan Environment, Sikkim Regional Centre, Pangthang-737101, Sikkim
**Corresponding author email: dr.rajeshjoshi@gmail.com*

Spring water, emerging naturally from confined and unconfined aquifers, is the primary resource for sustenance of life in the Himalayan region. However, due to change in land-use patterns, climate, increasing demand of growing population and various other factors, large number of springs in Himalaya are drying up leading to new challenges to rural communities. Nearly 8,000 villages across the Indian Himalaya are under acute water shortages due to drying up of springs. In the Kumaun region of Uttarakhand, nearly 75% of the springs have gone dry during last 4-5 decades. This scenario calls for improved understanding of water balance (i.e. demand-supply patterns), social governance system, and geo-hydrological dynamics of ground water with the perspectives of aquifers that act as storehouse or the source. Realizing this, a systematic and collaborative approach of Spring-Shed Management (SSM) was applied for spring water augmentation in pilot site of Kailash Landscape in Uttarakhand. Based on the preliminary results, pre-and-post analysis of the interventions reveals that the discharge of selected springs has increased by 20% during post monsoon, 19% during winter and 16% during pre-monsoon/ dry season. The results of pilot sites are indicative that integration of geo-hydrology and ecosystem based approach along with community participation is a prerequisite for success of any water recharge interventions. The findings shows that for effective planning and implementation for spring rejuvenation in the Himalaya requires effective integration of science based approach with the customary bio-engineering interventions, and building synergy amongst diverse stakeholders, including community and community based organizations is crucial.

Key words: *Spring, Spring Shed Management, Water Sustainability, Himalaya*

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A LONG TERM STUDY ON IMPROVEMENT OF PRODUCTIVITY, PROFITABILITY AND SOIL PROPERTIES IN MINT (*Mentha arvensis* L.) BASED DIVERSIFIED CROPPING SYSTEM

Abdul Mazeed*, Nikil B. Lothe, Arvind Kumar, Vishnukant Patairiya, Khushboo Khan, Priyanka Suryavanshi and Rajesh Kumar Verma*

Division of Agronomy and Soil Science, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015
**Corresponding author email: abdulmazeed0007@gmail.com*

A long term experiment was conducted (2012-2019) to study the effects on yield attributes and soil properties in aromatic crop (menthol mint) based cropping systems. In the study we have exclusively focused on the improvement of agricultural income and soil health through integration of menthol mintespecially, in summer season which are fallow (March-June) in north India. Profitability of the crop and major soil chemical properties were tested with five crop rotations along with menthol mint, viz., T_1- Paddy-Potato-Mentha; T_2- Paddy-Mustard-Mentha; T_3- Paddy-Wheat-Mentha; T_4-Paddy-Pea-Mentha; T_5- Paddy-Gram-Mentha. Research findings would help in providing information about mentha and other agricultural crops, their production cost, economical indices and profit earned by farmers in access to mentha based diversified cropping systems. Maximum gross return (513669.1 INR), net return (437469.1 INR) and benefit cost ratio 5.74as well as sustainability of soil (N-205.3 kg ha^{-1}, P-66.07kg ha^{-1}, K-220.19kg ha^{-1} and SOC (0.37%) as per post-harvest analysis of soilwas found in T_4 followed by T_5.

Key words: *Mentha, Productivity, Profitability, Crop rotation, Soil sustainability.*

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GLOBAL WARMING AND ITS IMPACT ON CROP PRODUCTION

Kishan Kumar*, Ram Niwas and Pankaj Kumar Singh

Ph.D. Research Scholar, CSA University of Agriculture and Technology Kanpur U.P.
**Corresponding author email: krishnavermaupc@gmail.com*

Agriculture is the backbone of Indian economy which in turn relies on the monsoon season. Rising global temperature is not only causing climate change but also contributing to the irregular rainfall patterns. Uneven rainfall patterns, increased temperature, elevated CO2 content in the atmosphere are important climatic parameters which affects the crop production. Research studies indicate that weathering parameters influence strongly (67%) compared to other factors like soil and nutrient management (33%) during the cropping season. The Intergovernmental Panel on Climate Change (IPCC) projected that the global mean surface temperature will likely rise and may result into uneven climatic changes. This rising temperature may affect crop yield at large scale. It has been reported over 20^{th} century that rising temperature plays an important role towards global warming as compared to precipitation. Researchers have confirmed that crop yield falls by 3-5% for every 1°F increase in the temperature. Global warming has become a major scientific and political issue during the last decade. The global temperature had risen by 0.4 ^{0}C over the last years because of rapid industrialization, it has increase about 0.5-1.0^{0}C in last century. If this trend continues, global warming of approximately 0.5^{0}C by 1995-2005, 1.5^{0}C by 2015-2050 and 3^{0}C 2050-2100, with greater increased taking place at higher latitudes, has been predicted.

Key words: *Atmosphere, Global warming, IPCC, Nutrient Management, Precipitation*

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PERFORMANCE OF POLYCOATED UREA *VIZ-A-VIZ* NEEM COATED UREA IN WHEAT-RICE CROPPING SEQUENCE IN PUNJAB, INDIA

Rajan Bhatt[1], Manmohanjit Singh[2] and Vivek Sharma[3]

[1]Punjab Agricultural University, Regional Research Station, Kapurthala, Punjab, 144 620,[2]Punjab Agricultural University, Regional Research Station, BallowalSaunkhri, Distt SBS Nagar Punjab, 144 521,[3]Department of Soil Science, Punjab Agricultural University, Ludhiana, 141004 India

**Corresponding author email: rajansoils@pau.edu*

Poly coated urea (PCU 42% N) as compared to neem coated urea (NCU 46% N) is a controlled release N fertilizer designed to release N-nutrient into soils as per nutrient absorption by the plants, thus decreasing N losses and improve N-use efficiency. Present studies were carried out from 2015-17 at Ballowal-Saunkheri (under irrigated and rainfed conditions) and Tarn Taran (Irrigated conditions) under rice-wheat cropping sequence. Under irrigated condition during *Rabi* season, average grain yield of wheat increased significantly with the application of recommended NCU and PCU over the control as well as 50% recommended N through PCU treatment while yield attributing traits viz., spike length, number of tillers and 1000-seed weight increased significantly over the control treatment. Further, chlorophyll content (chl-a, chl-b and total chl) was highest with treatment 50% N - PCU and 50% N - NCU, which was statistical at par with all the treatments except control. Further, among nutrient uptake, average maximum nitrogen uptake (33.2 kg/ha) was recorded with T_4 while in phosphorus, maximum uptake was recorded with treatment T_6 and in potassium, maximum uptake was recorded with treatment T_6. Under rainfed conditions, complete crop failure observed during the 2015-16. However, during 2016-17, NCU and PCU significantly increased the grain and straw yield over control. The grain yield was maximum with the treatment T_4 (75% recommended nitrogen with PCU through split doses) which was statistically at par with other treatment except control and T_5 (50% recommended nitrogen with PCUin split doses). Among different yield attributes, spike length and 1000-seed weight increased significantly with the application of urea through NCU and PCU over the control. Nitrogen, phosphorus and potassium uptake in grain increased significantly with the application of NCU and PCU over the control. Onfarmers' field at Tarn Taran variations in grain and straw yield was found to be non-significant, while periodic biomass (kg/ha) was significant. However, at University Seed Farm, Usman, Tarn Taran maximum grain yield (84 q/ha) was obtained with treatment T_3 as N uptake was maximum in T3. Further, there is a need to recheck these results under texturally divergent soils in different agro-climatic conditions for delineating applicability of PCU over a large area in the rice-wheat cropping sequence.

Key words: *Controlled release fertilizers, Grain yields, Polycoated urea, NPK uptake*

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ENCOURAGE THE ORGANIC PRODUCTION SYSTEM ON MEDICALLY IMPORTANT PLANT KALMEGH (*Andrographis paniculata* L.) THROUGH APPLICATION OF BIOLOGICAL FERTILIZERS

Vishnnukant Patairiya, Arvind Kumar, Geetu Singh, Rajnish Kumar, Abdul Mazeed Nikil B. Lothe, Riya Mehotra, Neelu Yadav and Rajesh Kumar Verma

Department of Agronomy and Soil Science, Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), PO CIMAP, 226015, Lucknow, India

The experiment was conducted at research farm (26.5æ%N,80.5æ%E)of CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow, India located at 120m above mean sea level. The CSIR-CIMAP released kalmegh (*Andrographis paniculata* L.) variety CIM Meghawas taken which is popular among the growers and commercially cultivating for production of important constituent andrographolide for

tropical and subtropical regions of India. Four treatments were consisting i.e., T_1 = 1.5 t ha^{-1} vermicompost + *Pseudomonas monteilii*, T_2 = 1.5 t ha^{-1} vermicompost +*Cedeceadavisae,* T_3 = 1.5 t ha^{-1} vermicompost + *Cronobacter dublinensis,* T_4 = 1.5 t ha^{-1} vermicompost +*Advenella species* with five replicationsfor the field study. The bacterial strains were obtained from the division of Plant Protection and Microbial Technology from CSIR-CIMAP, Lucknow, India. Results revealed that the leaf: stem ratio, biomass yields and quality were significantly improved with application of various bioinculants. The maximum dry biomass yield and andrographolide content were 10.2 t $ha^{-1}$and 119. 854 kg h^{-1}, respectively in T_2 treatment.

Key words: *Kalmegh, CIM Megha, bio-inoculants, andrographolide, vermicompost*

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INFLUENCE OF MICRONUTRIENTS AND BIO-INOCULANT ON GROWTH, YIELD AND OIL QUALITY OF MENTHOL MINT (*Mentha arvensis* L.)

Nikil B. Lothe, Abdul Mazeed, Vishnukant Patairiya and Rajesh Kumar Verma*

Division of Agronomy and Soil Science, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow-226015

**Corresponding author email: rajesh.verma@cimap.res.in*

A field experiment was conducted at research farm of CSIR-CIMAP, Lucknow during 2018-19 to evaluate the effects of application of various micronutrients and bio-inoculants along with recommended dose of NPK (150:60:40) on growth, fresh herb yield, oil yield, and quality of menthol mint (*Mentha arvensis* L.). All yield and oil quality parameters were tested for six treatment combinations including control, viz., control (T_1): NPK (150:60:40); T_2: NPK (150:60:40) + Sulphur; T_3: NPK (150:60:40) + Zinc sulphate; T_4 : NPK (150:60:40) + Iron sulphate; T_5: NPK (150:60:40) + Zink sulphate + Iron sulphate; T_6 : NPK (150:60:40) + *Cedeceadavisae* (PGPR) The increase (%) in fresh herb and oil yields of menthol mint was 17.81 % and 13.97 %; 36.17% and 38.0 %; 32.28 %, and 38.05 %; 22.08 and 7.53%; 27.18 % and 20.25 %, respectively in T_2, T_3, T_4, T_5, T_6 over control (T_1). The maximum fresh herb yield was found in T_4 (NPK 150:60:40 + Iron sulphate) however oil yield in T_3 (NPK 150:60:40 + Zinc sulphate). The quality of the menthol mint is acceptable in the market and no significant variation was observed amongst the treatments.

Key words: *Bio-inoculant, Herb yield, Menthol mint, Micronutrients, NPK*

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ORGANIC FARMING: TIME DEMANDING ECO-FRIENDLY APPROACH FOR SUSTAINABLE AGRICULTURE

Akhilesh Kumar Tiwari[1*], D.K. Sharma and V.K. Mishra[1]

ICAR-CSSRI, Regional Research Station, Lucknow (U.P) [1]

**Corresponding author email:a8604210800@gmail.com*

Organic farm products are becoming valuable over inorganic products with increasing awareness in the society. Society is becoming more and more conscious for health and environment over the globe. Bio-farming is sustainable and eco-friendly and enables the society to conserve biodiversity and improvement in environment quality. Organic farming system avoids use of synthetic compounds such as fertilizers, plant protection chemicals, growth regulators, and livestock feed additives. Organic farming mainly relies upon crop rotation, organic manures, bio-pesticides and integrated pest management (IPM). The present paper deals with needs for organic farming, bio-pesticides, and preparation and use of organic manures by different methods in a hygienic manner. Organic farming differs from conventional agricultural production and avoids use of chemical fertilizers and synthetic pesticides and herbicides.

Harvests are consequently smaller than in conventional production. Income losses are compensated by paying farmers organic farming aid, which is a form of supplementary environmental support. One problem is the loss of foods' organic status in some part of the production chain, which means they no longer meet the requirements set for organic production. The audit indicated that less than one-fourth of organic farms are not affected by this problem. The small amount of animal's inorganic production contributes to the loss of foods' organic status, along with slack demand. Feeds that have been produced organically end up being fed to animals that are in conventional production.

Key words: *Organic farming, Bio-pesticides, Organic manures*

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FUTURE PREDICTION OF LULC CHANGE OVER A HIMALAYAN WATERSHED IN NORTH INDIA

Bhagwat Saran[1*] and Anil Kumar[2]

[1]*Research Scholar, Department of Soil and Water Conservation Engineering, College of Technology, Govind Ballabh Pant University of Agricultural and Technology, Pantnagar, Uttarakhand, India*

[2] *Professor, Department of Soil and Water Conservation Engineering, College of Technology, Govind Ballabh Pant University of Agricultural and Technology, Pantnagar, Uttarakhand, India*

**Corresponding author email: saran.bhagwat007@gmail.com*

Impact of land-use land cover (LULC) changes is important on the water balance of any watershed or basin. Understanding the impacts of land-use land cover changes on hydrology of the watershed and provide information for water resources management planning. This paper covers the prediction of future land-use land cover of the Naulahimalayan watershed, in the state of Uttarakhand, India. Land-use information derived from the satellite imaginaries and their integration with geographical information system (GIS), used for future prediction of land- use land cover of the Naula watershed. Land-use land cover changes prediction used to analysis the prediction landslides, erosion, land planning climate change of the Naula watershed.Sustainable water resource development strategies, is essential to establish interaction between landuse changes and local hydrology through proper assessment. LULC affects hydrologic regimes, evaluating which LULC shall be appropriate for the local hydrological regime can help decisionmakers to incorporate in the policy makers of the watershed. This study assesses to changes of LULC and its impacts on future water balance of the Naula watershed of Uttarakhand state.

Key words: *LULC, Naula, Prediction, RS & GIS*

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SUSTAINABLE MANAGEMENT OF FUSARIUM WILT OF BANANA USING POTENTIAL ISOLATE CSR-D-4

Kavita Yadav[1*], T. Damodaran[1], Ram Gopal[1] and Kakoli Dutt[2]

[1]*ICAR- CSSRI, Regional Research Station, Lucknow – 226002, Uttar Pradesh, India*

[2]*Banasthali Vidyapith, Jaipur- 304021, Rajasthan, India*

**Corresponding author email: kavitayadav20451@gmail.com*

Fusarium wilt disease caused by *Fusarium oxysporum* f. sp. *cubense* Tropical race-4 (Foc) is a major disease devastating banana plantations worldwide. The pathogen is soil-borne and persists for more than 30 years in the soil. Chemical control of Fusarium wilt in bananas has not been successful. Alternatively, biological control is one strategy that need to be exploited to inhibit the growth of the pathogen. The invasion of the disease in the sub-tropical zones of India comprising of major banana growing regions of Uttar Pradesh and Bihar in an extensive manner warranted the need to develop

control measures to check the proliferation and manage the disease using biological agents. With this background the current study was undertaken to isolate the potential bacterial antagonist from the disease suppressive soils where G-9 cultivar of banana is being taken as monocrop and is being infected with the disease continuously over a longer period. The study was also aimed to identify the potential antagonist and to investigate the possible mechanism involved in the control if occurred. Extensive survey in the hot spot regions of the Faizabad district where the disease was first reported from the country resulted in the isolation of 45 bacterial isolates that was later grouped to 15 based on elimination of similar isolates. Screening of the isolates under dual plate resulted in identification of the isolate CSR-D-4 (*Bacillus licheniformis*) which showed 80.17% of inhibition to the Foc TR-4. Pot culture experiment under isolated green house with 30 days old tissue culture G-9 cultivar showed that the isolate significantly decreased disease incidence, resulting in the disease scoring index of 1. Biochemical studies indicated the significant increase in polyphenol oxidase (PPO), and peroxidase (PO) in the plantlets treated with CSR-D-4 and Foc TR-4 than the plantlets treated with Foc TR-4 alone and the untreated control. *In vivo* biocontrol assays showed a significant reduction in wilt index and vascular discoloration. These results indicated that the antagonistic mechanism against Fusarium wilt was involved in the inhibition of mycelial growth and the improvement in activity of defense related enzymes.

Key words: *Disease suppressive soil, Bacillus licheniformis, Fusarium oxysporum f. sp. cubense*

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CHARACTERIZATION OF VARIETAL IDENTIFICATION AND SEED VIGOUR STUDIES IN INDIAN MUSTARD [*Brassica juncea* (L.) CZERN & COSS.]

Himanshu Rai*

Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar- 125004 (Haryana)
**Corresponding author email: himanshurai.ag@gmail.com*

The present experiment was conducted in the Department of Seed Science and Technology, Chaudhary Charan Singh Haryana Agricultural University, Hisar with the objectives of identifying stable diagnostic characteristics of seeds, seedlings and plant morphology of different varieties of Indian mustard, differentiating the Indian mustard crop varieties by using chemical tests and assessing the seed vigour and determining the reliable predictor (s) of seedling establishment in Indian mustard. The experimental material for present study consisted of 20 Indian mustard varieties. These were evaluated in field and laboratory conditions in randomized block design and completely randomized design with three replications, respectively. Based on morphological, physiological and chemical parameters, these varieties were categorized into different groups. Phenol test in combination with some morphological characters proved very useful parameter in differentiating all the 20 varieties of Indian mustard. Different vigour and viability tests were conducted to assess the seed vigour potential of Indian mustard varieties. These tests were test weight (g), standard germination (%), seedling length (cm), seedling dry weight (mg), seedling vigour index-I, seedling vigour index-II, accelerating ageing test (%), electrical conductivity test (ìS $cm^{-1}g^{-1}$), tetrazolium test (%), dehyrdogenase activity test (OD $g^{-1}ml^{-1}$), oil content (%), emergence index, mean emergence time and seedling establishment (%).

Key words: *Characterization, Classification, Chemical, Evaluation, Variety, Vigor, Indian mustard*

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WEED MANAGEMENT IN MEDICINAL AND AROMATIC CROPS UNDER ORGANIC FARMING

Priyanka Suryavanshi*, Dipender Kumar†, Pooja Maurya, Abdul Mazeed and Shriram Rajvanshi

** Division of Crop Production and Protection, CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow, 226015, India*

†CSIR-Central Institute of Medicinal and Aromatic Plants, Research centre, Pantnagar

**Corresponding author email: priyanka@cimap.res.in*

Organic farming is gaining momentum in India mainly due to soil, livestock and human health concerns. Medicinal and aromatic plants (MAP) are two related groups of plants having chemical constituents which are active in curing ailments or in providing flavors and/or fragrances. USDA study team on organic farming defines it as a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, offfarm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection. Organic agriculture is developing rapidly and today at least 170 countries produces organic food commercially. There were 43.1 million hectares of organic agricultural land in India including in conversion areas and with 2 million producers. Weeds compete with crop plants for water, nutrients, space and reduce crop yields. In organic farming, manual weeding, weeding through cultural methods like hoeing, mulching and intercropping are widely practiced to manage weed population and increase crop yields. Various researchers have worked in this area in India which is summarized in this review. Organic mulch (menthol mint distillation waste with 20% moisture), intercropping with cowpea and black gram were found superior to control and herbicides in controlling weeds in medicinal yam (*Dioscorea floribunda*). Medicinal yam + black gram combination was found most economical. Hand weeding, mulching with spent grass, close spacing produced significantly higher biomass and essential oil yields of citronella in comparison to control. Intercropping with green gram also increased essential oil content. Organic mulch with citronella spent grass effectively controlled weeds and increased biomass and oil yields of aromatic grasses citronella, palmarosa and lemongrass and succeeding menthol mint crop. Intercropping with menthol mint reduced weed growth by 40 % and did not reduce the yields of rosescented geranium. *Withania somnifera* along with other agricultural crops as trap crops controlled broomrape parasite of opium poppy (*Papaver somniferum*) by inducing germination of the parasite through allelochemicals and subsequently killing it as none of the trap crops were hosts for the parasite. *Mucuna pruriens* was used a cover crop for weed control and as living mulch in fruit crops reducing use of herbicides and synthetic chemicals. The weeds were controlled through allelochemicals released by the crop. Long-term organic farming experiments on medicinal and aromatic crops are needed to study impact of organic nutrients and bio-pesticides on crop productivity, soil processes, carbon sequestration, soil organic matter dynamics, nutrient cycling etc.

Key words: *Organic farming, medicinal and aromatic crops, organic mulch, intercropping, allelochemicals*

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UTILISATION OF BAEL WASTE FOR ANIMAL FEED PRODUCTION

Balvindra Singh, Supriya Vaish, Sanjay Kumar and Neelima Garg*

Division of Post Harvest Management

ICAR-Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow-226101, India

**Corresponding author email: neelimagargg@rediffmail.com*

A huge quantity of fruits and vegetables get wasted during different post harvest operations. FAO (2014) revealed that in the developed parts of China, India, Philippines and the United States alone approximately 55 MMT of fruit and vegetable waste is generated. Reduction, reuse, recycle fruit and vegetable waste is a necessity as well as a challenge. Novel technologies can be useful for management of this waste. The study reports utilization of bael waste for production of animal feed enzyme using a consortium of seven microbes. Bael waste (fibre and mucous) waste was collected from processing lab of Post Harvest Management Division of the Institute. It was homogenized with water (1:1.5) in a grinder. The waste was autoclaved at 121^{0}C for 15 minutes and inoculated with microbial consortium including *Lysinibacillus sphaericus, Bacillus pacificus*, *Microbacterium sp., Bacillus mycoides, Stenotrophomonas maltophilia, Acinetobacter schindleri, Bacterium ARB19.* The inoculated waste was stored at 35^{0}C for a period of 10days. Samples were withdrawn at 2 days intervals and analyzed for pectinase, cellulase and amylase activities. Highest Enzyme production viz. pectinase (454.0 U/ml/min), cellulase (451 U/ml/min) and amylase (483.7 U/ml/min) was observed after 48 hours of incubation. The enzyme yield decreased thereafter and was minimum after 10days of incubation. The study revealed that bael waste could be successfully utilized for use as substrate for production of animal feed enzyme and within a span of 48 hours maximum yield could be obtained.

Key words: *Bael waste, Animal feed enzyme, Microbial consortium*

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CONSERVATION OF ENDANGERED, RARE AND THREATENED PLANTS BY MODERN TECHNIQUES OF PLANT TISSUE CULTURE

Prapti Singh, C.K. Tiwari and Shalini Purwar*

Department of Basic and Social Sciences, College of Forestry, Banda University of Agriculture and Technology, Banda, 210001, Uttar Pradesh, India

**Corresponding author email: purwarshalini@gmail.com*

Plants are the spine of life on Earth. As per study plants evolved on Earth by about 700 million years ago, and there are 391,000 plant species, out of which 3700 endangered plant species and 100,000 plants are threatened with extermination. This is due to over exploitation and for some other reasons like climate change, habitat destruction, and invasive species over collection water unavailability,human activity like excess deforestation. Conservation of plant is required to control the devastating effects on ecosystem. Conservation of plants can be achieved by developing novel techniques that can produce plants on large scale, which deliberately guide to conserve the endangered, rare and threatened plants. Plant tissue culture is one such modern technique that can be used to produce plants with desired traits and irrespective of season. Plants tissue culture is a modern biotechnology method that aims to produce disease free plants in an artificially controlled and aseptic environment. Any part of the plant like stem, sucker, leaf, cell or tissue can be used as explant to produce 100 clones of the same plant. This technique surely proves to be an aid to cure this serious issue of conservation of RET plants. Tissue culture protocol have been developed for a broad range of RET plants like *Bacopamonnieri*, *Rauwolfia serpentina*, *Ramonda serbica*, *Ramonda nathaliae*, *Ilex khasiana*, *Podophylum hexandrum*, *Rhododendron macabeanum*, *Vanda*

bicolour, *Aconitum nagarum*, *Hypericum gaitii*, *Podophyllum hexandrum*, *Rhododendron wattii*. Tissue culture techniques along with molecular breeding are successfully used for gene transfer of specific traits. Tissue culture techniques anther culture, protoplast fusion, ovule and embryo culture have been used to create genetic variation in breeding lines. *In-vitro* propagation also acts as practicable alternative for increase and conservation of populations of existing bio resources in the wild and to meet the commercial requirements. Thus, *in-vitro* tissue culture methodology proves to be a tool of conservation to ensure the survival of endangered plant species.

Key words: *Conservation, Endangered plants, Plant tissue- culture, Micro-propagation*

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SOIL PHOSPHORUS FRACTIONS IN DIFFERENT SOIL ORDERS OF INDO-GANGETIC PLAINS OF INDIA

Arbind Kumar Gupta[1]*, L.K. Tripathi[2] and P.K. Patra[3]

[1]Assistant Professor, Banda University of Agriculture & Technology, Banda, UP

[2]Assistant Professor, ITM University, Gwalior, MP

[3]Professor, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, WB

**Corresponding author email: arbind4gupta@gmail.com*

The study was conducted to quantify the status and distribution of phosphorus pools of some soil orders and evaluate their relationship with soil characteristics under Indo-Gangetic plains of India. Soil samples were collected from three depths (0-15, 15-30 and 30-45cm) of different cultivated field covering Entisols, Inceptisols and Alfisols soil order of India. The soil maps (released by NBSS&LUP, Nagpur) and GPS were used during collection of soil samples. The collected soil samples were analysed for physical, chemical properties and different phosphorus fractions. Among different phosphorus fractions, Ca-P was dominant and contributes 35% and 20% of total phosphorus in Entisols and Inceptisols respectively followed by Fe-P, RS-P and OC-P while Fe-P contributes 21% followed by Ca-P, RS-P and Al-P in Alfisols. Depth wise distribution of P fractions, Al-P, RS-P and Ca-P was lower in upper layer and increased with soil depth whereas organic-P and available phosphorus was higher in upper layer and decreased with depth in all soils. Fe-P and Al-P had significant and positive correlated with available P and negative with Soil pH in Entisols and Inceptisols while OC-P and Ca-P had positive correlation with soil pH in Alfisols. Overall contribution of Ca-P is highest in Entisols (35%) and Inceptisols (20%) while Fe-P (21%) in Alfisols among different phosphorus fractions. It may be concluded that the inorganic phosphorus predominates over organic fraction. Among the inorganic P fractions, Ca-P was the dominant contributor to the availability of phosphorus for Entisols, Inceptisols and iron phosphate was the dominant fraction for the release of P for Alfisols in Indo-Gangetic plains of India.

Key words: *Correlation, Inorganic phosphorus, Soil depth, Soil orders, Soil Properties*

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SOIL ACIDITY AND NUTRIENT AVAILABILITY AS INFLUENCED BY ORGANIC SOURCES WITH AND WITHOUT RICE STUBBLE

Anupama Das[1], Prantika Kakati[2], Suravi Nandy[3] and Nilay Borah[4]

Department of Soil Science, Assam Agricultural University, Jorhat 785013 Assam

[1&2]PG Students; [3]TA, RFRI, Jorhat; [4]Professor, College of Horticulture

A laboratory experiment was carried out to evaluate nutrient availability and forms of soil acidity as influenced by organic manures with and without rice stubble addition. Bulk surface (0-15 cm) soils (sandy clay loam with pH 5.0 and organic carbon 5.8 g/kg), collected from winter rice (variety - Ranjit)

field after harvest of the crop, were processed and used to fill the poly plastic (PP) containers (diameter 9.6 cm, volume 500 cm^3). Two sets of containers, one incorporated with rice stubble (1.5 to 2.0 cm long) @ 4500 kg/ha and another without rice stubble were fertilized with farmyard manure (FYM), enriched compost (EC), poultry manure (PM) and vermicompost (VC) @ 2 t/ha and incubated for 56 days. The treatments were replicated three times and the containers were kept at ambient temperature under field capacity moisture in a completely randomized design. Irrespective of sources, the soil pH increased and exchange acidity, exchangeable aluminum and total acidity decreased due to addition or organic manures. The degree of changes in forms of acidity and soil pH was less prominent with stubble incorporation. Application of organic manures, except poultry manure, increased the available phosphorous and potassium content of soils after four weeks till eighth week of the treatment. The NH_4-N and NO_3-N contents in soil increased up to 6th week of incubation due to addition of organic manures, except for poultry manure. Incorporation of rice stubbles had a positive effect on nitrogen mineralization and availability of phosphorous and potassium.

Key words: *Organic manure, Rice stubble, Soil acidity*

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INFLUENCE OF LIME AND FARMYARD MANURE ON SOIL ACIDITY AND NUTRIENT AVAILABILITY WITH AND WITHOUT RICE STUBBLE

Prantika Kakati[1], Anupama Das[2], Suravi Nandy[3] and Nilay Borah[4]

Department of Soil Science, Assam Agricultural University, Jorhat 785013 Assam

[1&2]PG Students; [3]TA, RFRI, Jorhat; [4]Professor, College of Horticulture

A laboratory experiment was carried out to evaluate forms of soil acidity and nutrient availability as influenced by lime and farmyard manure (FYM) with and without rice stubble addition. Bulk surface (0-15 cm) soils (sandy clay loam with pH 5.0 and organic carbon 5.8 g/kg), collected from winter rice (variety - Ranjit) field after harvest of the crop, were processed and used to fill the poly plastic (PP) containers (diameter 9.6 cm, volume 500 cm3). Two sets of containers, one incorporated with rice stubble (1.5 to 2.0 cm long) @ 4500 kg/ha and another without rice stubble were treated with ½lime requirement (LR) followed by FYM 2 t/ha, ½LR followed by 2 t/ha FYM and 2 kg/ha wood ash, lime 20 kg/ha-FYM 2 t/ha-wood ash 2kg/ha as mixture, and 75:60:60 kg/ha N:P_2O_5:K_2O as urea, single super phosphate, muriate of potash, respectively. The treatments were replicated three times and the containers were incubated for eight weeks at ambient temperature under field capacity moisture in a completely randomized design. Application of lime significantly increased soil pH and decreased exchange acidity, exchangeable aluminum and total acidity compared to lime-FYM-ash mixture or fertilizer application and control. However, addition of lime-FYM-ash mixture increased soil pH and decreased forms of acidity significantly over control or fertilizer application. Incorporation of rice stubble affected the degree of changes in forms of acidity and soil pH in separate applications of lime (½LR), FYM and wood ash but not with lime-FYM-ash mixture. Application of mineral fertilizers significantly increased the available phosphorous and potassium content of soils up to eighth week of incubation. In case of lime and FYM, no significant difference in available P and K contents of soils was observed between their separate or combined applications. However, incorporation of rice stubble showed positive effects on P and K availability due to lime-FYM-ash mixture application. The NH_4-N and NO_3-N contents in soil increased up to 2nd week of incubation due to addition of mineral fertilizer, and was at par thereafter with combined or separate applications of lime and FYM. In case of nitrogen mineralization, incorporation of rice stubbles had a negative effect for mineral fertilizer application and a positive effect for separate or combined applications of lime and FYM.

Key words: *FYM-lime mixture, Rice stubble, Soil acidity*

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SUSTAINABLE PRODUCTION OF STRAWBERRY (*Fragaria X ananassa* DUCH.) IN PARTIALLY RECLAIMED ALKALI SOIL OF CENTRAL UTTAR PRADESH

Neeraj Kumar Verma[1*], R.B. Ram[2], T. Damodaran[1], V. K. Mishra[1] and Prem Kumar[2]

[1]CSSRI, Regional Research Station, Lucknow, [2]Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow 226025 (UP) INDIA

**Corresponding author email: neerajpbt@yahoo.com*

Application of synthetic fertilizers has improved yield per unit area manifold but these fertilizers are expensive and hamper the ecological balance of the soil. Excessive and unbalanced use of synthetic fertilizers leads to degradation of physico-chemical properties and microbial status of soil. The balanced application of organic manures, bio-fertilizers and inorganic fertilizers will enable higher production of quality berries and runners. Therefore, an alternate source of nutrition is needed to sustain productivity of land. The field experiment was carried out during 2017-18 and 2018-19 at the Horticulture Research Farm of the Department of Horticulture, Babasaheb Bhimrao Ambedkar University, Lucknow on Strawberry cv. Chandler grown on partially reclaimed alkali soil of central Uttar Pradesh. The experiment was laid out in Randomized Block Design with twelve different treatments along with control and planted in three replications of strawberry runners. The result revealed that maximum plant height, plant spread, leaf area, number of leaves per plant, number of fruits per plant, minimum duration of fruit harvesting, minimum days to first flowering, number of flowers per plant, size of fruit, volume of fruit, fresh fruit weight, dry fruit weight, fruit yield per plant and fruit yield per plot was recorded in T9: 75% NPK+MSWC + Mulch (Paddy straw) + Bio-inoculant and maximum length of leaf, width of leaf, size of leaf, length of petiole and length of pedicel was found in T1: 100% NPK + Mulch (Paddy straw) minimum was recorded under control respectively.

Key words: *Organics, FYM, MSWC, Growth and Yield*

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STUDIES ON SEED BORNE MYCOFLORA OF FODDER CROPS

Mamta Prajapati[1*], Y.P. Singh[1], Arjun Singh[1] and N. Manjunatha[2]

[1]ICAR- Central Soil Salinity Research Institute, Regional Station, Lucknow,

[2]ICAR- Indian Grassland and Fodder Research Institute, Jhansi (UP)

**Corresponding author email: pottermona94@gmail.com,*

The effect of seed borne fungi on germination and disease transmission are important factors in fodder seed production. Isolations were performed to get the composition of dominant fungal species. It was found that the seeds were infected with 9 fungal pathogens viz. *Aspergillus* spp., *Alternaria* spp., *Bipolaris* spp., *Colletotrichum* spp., *Curvularia* spp.*Fusarium* spp., *Penicillium* spp., and *Rhizopus* spp. This study also indicated that disinfection with hypochloride could not guarantee that all microorganisms will be killed. Rather sodium hypochlorite helped in minimizing the incidence of superficial and fast growing fungi like *Curvularialunata*, *Penicillium* spp. and *Rhizopus* spp. With increase in the incidence of seed borne myco-flora there was drastic reduction in rate of germination. The fungicide, carbendazim significantly retarded radial growth and spore germination of seed mycoflora at all concentrations. But, in case of *Fusarium* spp. carbendazim showed maximum effect at lower concentration but it failed

influencing at 20ppm. The present study revealed the efficacy of different concentration of nano-particles of CuO, ZnO and fungicide, carbendazim on the spore germination and radial growth of mycoflora. The effects of fungal pathogen were also retarded. It was found that nano-particles of CuO and ZnO prevented spore germination and radial growth may be due to their antifungal effect. In brief we conclude that different concentrations of CuO and ZnO nano-particles were most effective in retarding pathogens spore germination on all the test fungi.

Key words: *Antifungal, Fodder crops, Mycoflora, Nano-particles, Spore germination*

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IMPROVING SOIL FERTILITY AND YIELD AND QUALITY OF SUGARCANE THROUGH INTEGRATED PLANT NUTRIENT MANAGEMENT UNDER SUB-TROPICAL CONDITIONS

Om Prakash[1], Brahm Prakash[1], A.K. Sah[1], Pallavi Yadav[2] and A.D. Pathak[1]

[1]*ICAR- Indian Institute of Sugarcane Research, Lucknow*

[2]*CBG Ag PG College, BakshiKaTalab, Lucknow*

Sustainable agriculture is the successful management of resources for agricultural production to satisfy the human needs while maintaining or enhancing the quality of environment and conserving natural resources. Sugarcane is a long duration crop which accumulates large biomass in the life cycle. It exhausts substantial amount of plant nutrients from the soil. Sugarcane crop of 100 t/ha exhausts 208 kg nitrogen, 53 kg phosphorus and 280 kg potassium, in addition to 3.4 kg iron, 1.2 kg manganese, 0.6 kg zinc and 0.2 kg copper along with 30 kg sulphur. To restore soil fertility replenishment of these depleted plant nutrients is necessary either through chemical fertilizers, organic manures or through integrated use of chemical fertilizers and organic sources. But it is not possible to achieve the production and sustainability of soil as well as crops under highly intensive cropping systems by manures and fertilizers alone or by adding organic sources. The integrated plant nutrient management involves the use of chemical fertilizers in conjunction with organic manures/wastes coupled with inputs through biological processes, has proved its superiority over use of an individual component.

Integrated plant nutrient management systems not only help in restoring and sustaining soil fertility and crop productivity but also brings economy and efficiency of fertilizer by favourably affecting the physical, chemical and biological properties of soil. The choice of a crop preceding sugarcane has a considerable effect on the additional nutrient requirement for sugarcane. Ratoon crop of sugarcane requires 50% higher nitrogen and low requirement of phosphorus. Integrated nutrient management in sugarcane based system consists of various components like inclusion of inorganic chemical fertilizers, leguminous crops in cropping systems, organic manures, crop residues, factory by-products/effluents and balanced application of nutrients and fertilizer.An integrated use of legumes as sequential crop or as intercrop provides an excellent opportunity to restore and sustain the productivity of sugarcane agro-ecosystem. It helps in fixing atmospheric nitrogen to extent of 40-85 kg/ha with 20 to 40% gain in cane productivity. Decline in cane yield can be arrested by balanced application of nutrients of compost/ farmyard manure and more so by integrated use of chemical fertilizers and organic manure. An integrated use of trash (5 t/ha) with nitrogen has been found helpful in increasing cane yields by about 40% over control and economizes up to 50% of nitrogen requirement of sugarcane. A significant increase in cane yield has been noticed with an integrated use of filter cake and unused composted bagasse through vermicomposting techniques. Application of Azotobacter and Azospirillium reduces nitrogen requirement by 25%. Similarly, use of biofertilizer has been found effective in increasing yield level of cane by 10-25%. Thus, in nutshell, it can be concluded that integrated nutrient management plays a vital role in enhancing the productivity and quality of sugarcane. This is the need of hour to identify efficient integrated nutrient

supply systems for different agro climate conditions to make integrated nutrient management more efficient, cost effective and practical and sustaining the sugarcane productivity in a long team basis in sugarcane based intensive cropping system.

Key words: *Azotobacter, Azospirillium, Integrated nutrient management*

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SITE-SPECIFIC NUTRIENT MANAGEMENT PRACTICES FOR HIGHER CROP PRODUCTION AND SUSTAINING SOIL HEALTH

Pallavi Yadav[1], Om Prakash[2], Brahm Prakash[2]and Kamini Singh[2]

[1]CBG Ag PG College, BakshiKaTalab, Lucknow

[2]ICAR- Indian Institute of Sugarcane Research, Lucknow

Soil is an ecosystem full of life which is a biological organization of the plants, microorganisms and number of tiny living creatures like microbes, bacteria, and fungi etc. The soil life is very dynamic in nature. The combination of various organisms in the soil keep changing hour to hour and season to season as they constantly multiply, grow, die, disintegrate and decompose. Soil life depends on the continual replenishment of organic matter. Most popular organic farming practices, such as crop rotation, composting, green manuring and keeping the soil covered, help to increase the soil's organic matter and hence its biological activity. Traditionally, farmers were aware and practicing that type of farming which nurtured the biological life in the soil. The shift towards commercial agriculture and the need and greed to grow more in a limited period of time resulted in overuse of chemical fertilizers. Soil test based application of plant nutrient helps to realize higher response and benefit: cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization. Location specific fertilizer recommendations are possible for soils of varying fertility, resource conditions of farmers and levels of targeted yield for similar soil classes and environment. Development of sound nutrient management programme involves knowledge of a wide range of information. Soil test records are an important piece of required information, but other factors such as soil moisture conditions, land ownership/tenure, crop and cropping sequence, integrated pest management, cultural practices, environmental issues and other management items are important for developing sound nutrient management programmers.

The essential nutrients of soil are depleted at a much faster rate due to adoption of high yielding and intensive cropping system. It resulted in increased dependence of crops on fertilizer. Soil testing is one of the accepted methods for the economic use of fertilizer but there are many problems in making fertilizer recommendation based on only soil test values. Soil analysis and correlation approach, critical soil test level approach, agronomic approach, soil fertility cum soil survey, inductive approach based on soil test and crop response correlation, deductive approach based on soil test and crop response correlation and target yield approach are some of the important approaches of fertilizer recommendations for crops are being used for increasing the economic crop yield. The objective of these approaches is to utilize soil and fertilizer nutrients judiciously and effectively in a manner best suited to different agro-ecological conditions. Target yield approach is one of the most popular approaches of fertilizer recommendation being used for getting most profitable economic response. From the soil test crop response field experiments, it has been possible to derive three basic parameters like nutrient requirement in kg quintal of the produce, percentage contribution from soil available nutrients and percent contribution from added fertilizers towards making effective fertilizer prescriptions for specified yields.

Key words: *Site-specific nutrient management, Soil Health, Target yield approach*

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CARBON SEQUESTRATION POTENTIAL OF TREE BASED AGROFORESTRY LAND USE SYSTEMS

Sanjeev Kumar[1*], K.S. Verma[2], B.S. Rajput[1] and Dinesh Gupta[1]

[1]Department of Silviculture& Agroforestry, College of Forestry BUAT Banda -791102

[2]Professor and Head, Department of Environmental sciences, Dr. Y.S. Parmar University of Horti. & Forestry, Nauni, Solan, Himachal Pradesh – 173230

**Corresponding author email: drsanjeevagf@gmail.com*

Agroforestry landuse systems have been perceived as a potential carbon sinks and can contribute substantially to mitigate the global climate change hence the study involving five agroforestry systems viz. horti-pastoral (HP), silvi-pastoral (SP), agri-horticulture (AH), agri-silviculture (AS), agri-horti-silviculture (AHS) and one natural grassland (NG) system of Western Himalaya were undertaken at Nauni (30^0 51′ N and 76^0 11′E), Solan (HP). The region represents sub-humid sub-tropical to sub temperate climate with an altitude of 1250 m amsl. The experiment was laid in split plot design. Each landuse system was replicated thrice. Existing carbon stocks and relative carbon sequestration potential of six landuse systems were evaluated. Different land use systems had significant variation in their total biomass production levels over natural grassland. The SP system produced the highest biomass whereas minimum in NG. The AHS system produced the second highest biomass among the different systems despite having less number of trees. The total carbon stocks (Plant + soil) revealed the superiority of SP system followed by AHS system with their respective value of 101.69 and 54.31 tonnes ha-1. The relative carbon sequestration potential was also highest in SP system and minimum under AH system. The finding evinced that silvi-pastoral system can be a better option for carbon sequestration in general. However, in arable lands, agri-horti-silviculture system shall be a better system for this purpose.

Key words: *Agroforestry, Biomass, Carbon sequestration potential, Carbon stock, Climate change*

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DISCHARGE OF ENDOCRINE DISRUPTING CHEMICALS (EDCS) CONTAINING ORGANIC POLLUTANTS FROM PULP PAPER INDUSTRIES AS A CHALLENGE FOR CONSERVATION OF AQUATIC RESOURCES AND THEIR REMEDIAL STRATEGIES

Ram Chandra*

Department of Microbiology, Babasaheb Bhimrao Ambedkar University, Vidya Vihar, Raebareli Road, Lucknow, Uttar Pradesh-226025

**Corresponding author email: prof.chandrabbau@gmail.com; rc_microitrc@yahoo.co.in*

Pulp paper wastewater is major source of environmental pollution due to discharge of huge amount of recalcitrant residual organic pollutants even after secondary treatment. There is generation of 190-200m^3 of wastewater per ton of paper production. In India there is about more than 600 pulp paper industries which reflect the magnitude of the problem. The major identified compounds are:1-(2,5-dimethoxyphenyl)-propanol, 9,12-octadecadienoic acid(z,z)-2,3-dihydroxypropyl ester, Octadecenoic acid, trimethylsilyl ester, Pentadecanoic acid, ethyl ester, (5á)-cholest-7-ene, â-Sitosteroltrimethylsilyl ether, Silane, trimethyl[[(3â,5á)-stigmastan-3-yl]oxy]-, Pentane, 2-methyl-4-keto-2-trimethylsiloxy, 2-methoxy phenol, Phenol,4-ethyl-2-methoxy, 1-Tetradecene, Ethyl-2-octynoate, Tetradecanoic acid methyl

ester, Hexadecanoic acid, cis-9-Hexadecenoic acid, trimethylsilyl ester, Hexadecanoic acid, trimethylsilyl ester or Palmitic acid TMS, Octadecenoic acid, trimethylsilyl ester, Octacosane, Silane, [[(3â)-cholest-5-en-3-yl]oxy]trimethyl-, â-Sitosteroltrimethylsilyl ether; which has been reported not only as toxic due to contribution of pollution parameters i.e. BOD, COD, heavy metals etc. but also as Endocrine-disrupting chemicals (EDCs) with mutagenic properties. The recent study has shown the toxic effect to fish and mutagenic potential to other flora and fauna. Therefore, the detoxification of these compounds is essential prior to its discharge into the environment. The bio-stimulation and biodegradation has been found as effective technology for the detoxification of discharged effluent at tertiary stage treatment by providing the adequate source of nitrogen, carbon and oxygen. The identified potential autochthonous bacteria i.e. *Klebsiella pneumoniae* IITRCP04 (KU715839), *Enterobacter cloacae* strain IITRCP11 (KU715840), *Enterobacter cloacae* IITRCP14 (KU715841) and *Acinetobacter pittii* strain IITRCP19 (KU715842) were found capable for degradation of various recalcitrant organic compounds during bio-stimulation process. The use of bio-stimulation and bioaugmentation process may be an effective detoxification technology for pulp paper mill wastewater. Further, the detoxified wastewater can be re-used for sustainable development. Hence, the developed novel technology may be a boon for prevention of river pollution and conservation of aquatic resources.

Key words: *Pulp paper wastewater, Bio-stimulation, Biodegradation, Autochthonous bacteria*

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SUSTAINING SOIL FERTILITY THROUGH *IN SITU* CROP RESIDUE RECYCLING IN WINTER RICE-BASED CROPPING SYSTEMS OF ASSAM

Nilay Borah[1], Kashyap Porag Bezbaruah[2], Suravi Nandy[3], Prantika Kakati[4] and Anupama Das[5]

[1]Professor, [2]Project Assistant, KVK, Morigaon, [3,4&5]Post Graduate Students, Department of Soil Science, College of Horticulture, Assam Agricultural University, Jorhat 785013 Assam

Efficient *in situ* recycling of rice stubbles remains a major challenge in transplanted rice ecosystem irrespective of sole cropping or diversified rice-based cropping systems in Assam. In case of sole cropping, the rapid *in situ* composting methods are not feasible in terms of energy consumption and cost effectiveness. On the other hand, incorporation of rice stubble without succeeding crop may lead to significant loss of some of the available nutrients in later stages of decomposition coinciding with pre-monsoon and monsoon rains. The decomposition of left over stubbles following their incorporation just before the next rice crop, the usual practice followed in mono-cropping areas, had been implicated for adverse effects in terms of low carbon mineralization, methane emission, toxicity to roots etc. The stubble management needs careful approach for sustaining soil fertility and productivity of succeeding crop(s). The efficiency of rice stubble recycling is significantly influenced by stubble pre-treatment, choice of crop, establishment method, and nutrient and water management practices. The approach to *in situ* rice stubble management thus holds immense significance towards mission double cropping in transplanted rice fallow areas of the state for long term sustenance of crop productivity and soil fertility.

Key words: *Rice stubbles, Decomposition, Carbon mineralization, Methane emission*

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ACREAGE ESTIMATION OF VEGETABLE CROPS AND GIS DATABASE CREATION OF COLD STORAGE FOR PROPER FOOD SUPPLY MANAGEMENT USING REMOTE SENSING AND GIS TECHNIQUES

P.P.S. Yadav*, Surabhi Joshi, Avdhesh Kumar Dubey, Shailendra Pratap Singh and Ankit Pandey

Remote Sensing Application Centre – Uttar Pradesh, Lucknow
**Corresponding author email: ppsyadav77@gmail.com*

India is now the second largest producer of fruit and vegetables in the world and leader in several horticultural crops, namely potato, okra and other vegetables. The total area occupied by horticultural crop in India was 24.92 million ha and total production in 2017-18 was 295 million tonnes, whereas Uttar Pradesh contributes 9.8% of the area and 12.1% of the production. Remote Sensing Techniques have demonstrated its potentiality in providing information of the characteristics and spatial distribution of natural resources including agricultural resources because of their unique advantages of providing multi-spectral, multi-temporal and multi-spatial resolutions. The analysis work have been done with the help of ERDAS IMAGINE software, whereas themapping of all cold storages of Uttar Pradesh work have been donethroughdetail field work with the help of global position system (GPS) on the basis of cold storage list provided by district horticulture officer and the vegetable crop acreage and cold storage maps were generated using Arc-GIS software by integrating the information details.This study gives timely pre-harvest forecasts of crop acreage for avoiding the rottening vegetable and providing the timely storage in the cold store from field. The information of cold storage through Remote Sensing and GIS provides actual location (Global position system coordinates) maps of cold storage, distance from districts headquarter, market and also provide information of their storage capacity, current status of building information, distance from market, owner's name and their telephone numbers etc. This data is providing the acreage and cold storage information & facilitate the planning about storage of potato for better supply in off season. The maps of potato acreage and cold storage through Remote Sensing and GIS provides better information to planners and farmers to get opportunity of producing cash crops to get remunerative prices. This study has proven that the Remote sensing and GIS has been used as a valuable tool for viewing, analyzing, characterizing and making decisions about our natural resources. The annual growth rate is estimated to be 12.56%. Currently there are 1989 cold stores in Uttar Pradesh and they are capable of storing a produce of 16.97million tonnes.

Key words: *Remote sensing, GIS, GPS, acreage, Arc-GIS, ERDAS IMAGINE*

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STUDY ON PRODUCTIVITY IMPROVEMENT IN RECLAIMED SODIC SOIL AND BENEFITS IN SOCIO- ECONOMICAL STATUS

Ravindra Mishra*

ICAR- Central Soil Salinity Research Institute, Regional Research Station, Lucknow
**Corresponding author email: mishraravindra066@gmail.com*

Soil sodicity is a major problem in arid and semi-arid regions of Indo-gangetic plains in India. A large proportion of sodicity affected soils in Indo- gangetic areas occurs on land inhibited by resource poor small farmers. Several efforts have been made by central and state government to check soil

degradation and increase agricultural productivity through sodic land reclamation programmes. Land degradation due to sodicity is a major threat to agriculture in Indo-Gangetic plains. The sodic soils are widely distributed across the globe and occupy nearly 357.2 million hectares. India has 6.73 Mha of salt-affected soils, of which 3.72 Mha is sodic soils predominantly present in Indo-Gangetic plains. A Sodic Land Reclamation Projects implemented by Uttar Pradesh Bhumi Sudhar Nigam and funded by World Bank (UPBSN) was evaluated in terms of socio-economical aspect and soil productivity improvement. The obective of the project was to induce and enhance the utilization of appropriate soil reclamation technology (Gypsum, flooding, leaching and drainage) developed by Central Soil Salinity Research Institute, Karnal. The sodic soil reclamation projects were run into three phases viz. Ist phase (1994-2001), IInd phase (1999-2007) and IIIrd phase (2009-2017). During Ist,IInd and IIIrd phases of project it covers 10, 18 and 29 district of Uttar Pradesh and reclaimed area about 68,000 ha, 189,000 ha and 130,000 ha, respectively. In total 93% of small and marginal farmers were benefited during each three phases of the reclamation project and the number of beneficiary farmers were about 156,000, 367,000 and 240,000, respectively in all three phases. The total gain in production of rice-wheat cropping system from barren sodic land after reclamation were about 0 to 2.99 Mg ha^{-1}of rice and 0 to 2.60 Mg ha^{-1} of wheat during Ist phase, 0 to 3.22 Mg ha^{-1} of rice and 0 to 2.69 Mg ha^{-1} of wheat in IInd phase, while in IIIrd phase the productivity increased up to 0 to 35.00 Mg ha^{-1} of rice and 0 to 3.00 Mg ha^{-1} of wheat. The increasing trend of productivity simplifies that the income of farmers during Ist, IIndand IIIrdphase by production of rice increased up to Rs.103 crores, Rs. 377 crores and Rs. 668 crores respectively. Similarly the increase in economy of the farmers has also been recorded by the production of wheat to about Rs.108 crores, Rs. 356 crores and Rs. 594 crores (based on respected year's MSP) in Ist, IIndand IIIrdphase, respectively. The Increasing trend of productivity and the enhancement in farmer's income implies that the reclamation project undertaken by Uttar Pradesh Bhumi Sudhar Nigam with the technology developed by Central Soil Salinity Research Institute, Karnal. The livelihood security of the resource-poor farmers also was improved by reclamation of sodic soil. Reclamied sodic soil also increased the socio-economy status of the small and marginal farmers and it helped to strengthen food security of the country by changing the productivity from barren degraded sodic lands.

Key words: *Sodic soils, Indo-Gangetic plains, UPBSN, Reclamation, Livelihood security*

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FEED RESOURCES AND CONSTRAINTS RELATED TO LIVESTOCK REARING IN DISTRICT HAMIRPUR U.P.

S.P.S. Somvanshi[1*], Md. Mustafa, S.P. Sonkar, Prashant Kumar, Phool Kumari, Shalini and Chanchal Singh

BUAT-Krishi Vigyan Kendra, Hamirpur -210 505
**Corresponding author email: surya.somvanshi@gmail.com*

The feed resources comprise of both concentrate feed ingredients and forges which stand complementary to each other in relation to balancing of rations. Feeding and nutrition, besides playing a vital role in animal rearing account for 60-70 per cent of the total milk production cost. The study was under taken in four adopted villages of Krishi Vigyan Kendra of district Hamirpur U.P. Simple random sampling technique was used to select 25 dairy farmers from each village constituting total 100 respondents; the interview schedule developed for collecting the information through personal interview. The study revealed that animals depended on natural pastures; Concentrate consist wheat bran, barley, chunni, rice bran etc was provided mostly to lactating animals by 86 percent farmers but quantity was low (usually about 1-2 kg/day) with soakedmustard oil-cakes (Khali); Wheat and peas straw (dry fodder)

90 percent of farmers was using as dry roughages throughout the year. Over 57 percent, farmers growing Berseem and 22 percent Oat as green fodderduring Rabi season. Whereas in kharif season 49 % farmers taking Sorghum and Maize (green). Common vice in livestock rearing found in the Bundelkhand is Anna pratha - system of leaving the livestock free for grazing was commonly practiced during lean seasons as also during rainy season. Other constraints are Majority of the farmers were feeding neither salt nor mineral mixture. Most alternate feed resource used was dried fodder, roughages, tree leaves and shrub, reportedly used by 54 % of the respondents; 50% of the respondents also used wild grasses as feed resources. All of the respondents depended on grazing to meet the feed requirement of their animals. No knowledge about making silage for lean period. It is concluded that the farmers may be skilled through demonstration, gosthies, training, ICT approaches etc. adapting technological practicesfor alternate feed and fodder to enhance the production to minimize the detrimental losses on dairy production system.

Key words: *Feeding, Nutrition, Silage*

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STUDY FOR DEEPER GROUNDWATER RESOURCE IN HARD ROCK REGION USING REMOTE SENSING AND GEOPHYSICAL TECHNIQUE BY 1D & 2D ELECTRICAL RESISTIVITY METHODS (A CASE STUDY FROM ROBERTSGANJ BLOCK, SONBHADRA DISTRICT, UTTAR PRADESH, INDIA)

Anil Kumar Chaurasiya[1*], V. J. Ganvir[2], Arjun Singh[3] and Amaresh Kumar Singh[4]

Project Scientist, Aquifer mapping Project, Remote Sensing Application Centre, Lucknow U.P. India

[2]Scientist-SE& Head GWRD, Remote Sensing Application Centre, Lucknow U.P. India

[3]Scientist-SD, Remote Sensing Application Centre, Lucknow U.P. India

[4]Project Scientist, Remote Sensing Application Centre, Lucknow U.P. India

**Corresponding author email: anilchaurasiya6@gmail.com,*

vinitjganvir@gmail.com

Electrical resistivity method is a best and economical technique for groundwater prospecting in different geological terrain. In this paper we have chosen Robertsganj block of Sonbhadra district U.P, India. It is a hard rock terrain of Vindhyanchal region and mostly dependent on ground water for drinking, irrigation, and domestic purpose and this study have been taken because generally surface water bodies dried up in the summer season and faces acute water. The exploration of groundwater is a challenging task in hard rock terrain. In the present study, one-dimensional Vertical Electrical Sounding (1D-VES) geophysical technique using Schlumberger array and Two-dimensional Electrical Resistivity Tomography (2D-ERT) geophysical technique using two different arrays, Gradient and Dipole-Dipole. The vertical electrical resistivity data were collected using DDR-3 Instrument and 2D subsurface resistivity tomography data collected using Terrameter LS2 Lund imaging system and covered a 5.6 km long profile in a hard rock terrain. The hydrological interpretation based on resistivity model reveal the horizontal trap within the clayey sand and weathered/fractured sandstone/quartzite formations. Aquifer zone resistivity lies between 3 to 35 ohm-m and 100 to 150 ohm-m. The result of the resistivity models decipher potential aquifer lying between 40 and 60 meter depth, nevertheless, it corroborates with static water level measurements in the area of study. Thus the above study has clearly shown the capabilities of Remote Sensing, Geographical information system and Geophysical 2D techniques have proved worth which gives clear insight of the aquifer extent, variability and their dimension from shallow to deeper strata from the hydro geological prospective in the present geological context. Groundwater aquifer

generally occurs in weathered & fracture zone of the study area in Vindhyachal region is mostly found in sandstone and quartzite.

Key words: *Vertical Electrical Sounding (VES),Electrical Resistivity Tomography (ERT), Geophysical method, Satellite data (LISS IV& Cartosat-1 Merge data), District Resource Map of Sonbhadra (Geological Survey of India), Survey of India (SOI) toposheets*

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CARBON SEQUESTRATION BY BIOCHAR FOR SUSTAINABLE SOIL AND ENVIRONMENT

Anita Jaswal*

Department of Agriculture, Lovely Professional University, Phagwara (Punjab), 144411, India

**Corresponding author email: anitajaswal91@gmail.com*

Biochar is a fine grained, highly carbonaceous, pyrolysed product of biomass. Biochar is produced from burning organic material at high temperature with little or no oxygen availabilityby the process of pyrolysis. The conversion of organic matter into biochar and its incorporation to soil also decreases the negative effects of carbon aerosols on human health and greenhouse gas effects on environment through carbon sequestration. As the majority of biochar is carbon (70-80%), it can potentially contribute more carbon than plant residue. Soil C sequestration is the removal of atmospheric CO_2 through photosynthesis to organic matter which is ultimately stored in the soil as long-lived, stable forms of C .It is the long-term storage of carbon in soil which could be accomplished by the application of biochar as a soil amendment. Biochar being highly stable in soil due to its porous, recalcitrant nature and amorphous structure. Soils store three times carbon than exists in the atmosphere. Carbon sequestration refers to this process of storing carbon in soil organic matter and thus removing Carbon dioxide from the atmosphere. Physicochemical properties of biochar such as nutrient sorption capacity, pH, pore structure, particle size, surface area, and mineral content play a vital role in determining the soil structure and function. Biochar addition to soil exerts measurable changes in physicochemical soil properties such as bulk density, water-holding capacity, pH and cation exchange capacity, microbial community structure, and their interrelated functions in soil. However, addition of biochar to specific soil improves the soil fertility, and consequently improves the crop yield. It is concluded that optimized pyrolysis of organic waste for biochar production and its use for soils need diversified investigation in diverse environmental conditions. Therefore, optimisation of feedstock, pyrolysis temperature for preparation biochar and its application in a specific soil is extremely essential for stability of biochar and protection of native SOM and greenhouse gas reduction for long-term carbon sequestration.

Key words: *Biochar, Sequestration, Pyrolysis, Feedstock, Greenhouse gas*

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RHIZOSPHERE MANAGEMENT: A NOVEL APPROACH FOR SUSTAINABLE AGRICULTURE

Anshu[1*]

[1]Division of Soil Science and Agriculture Chemistry, Faculty of Agriculture*

Sher e Kashmir University of Agricultural Sciences and Technology, Chatha Jammu

**Corresponding author email: anshusharotri97@gmail.com*

Rhizosphere management is viewed as a novel approach for sustainable agricultural production by reducing our reliance on agrochemicals and replacing their functions with beneficial microbes in the

rhizosphere such as PGPR which through both antagonistic and synergistic interactions with the plants enrich the rhizosphere with the nutrients and promote plant growth, enhance resistance to stress and improve soil structure and organic matter content. Introduction of PGPR as inoculants ensures improved crop production through a diverse range of mechanisms such as biological nitrogen fixation, increasing the availability of essential elements like phosphorous and potassium and production of phytohormones and antibiotics in the soil. Rhizosphere management involves different strategies for manipulating root growth, rhizosphere modification, such as introduction of RMPs and BMPs in intercropping, use of efficient crop genotypes with an aim to exploit the biological potential for efficient nutrient acquisition by plant roots. Rhizosphere efficiency is also maximized in nutrient mobilization and acquistion by optimizing the inputs in intensive farming systems for high crop productivity and high NUE. Different biotechnological approaches are also practiced for better symbiosis and associations between soil biota and plants using techniques like nano biofertilizers encapsulation by micro encapsulation of the beneficial bacteria on to the plant roots of different crops and development of superior PGPR strains by improving required traits using genetic manipulations helps in modulation of sustainable agriculture by improving soil fertility, plant tolerance, crop productivity, and maintaining a balanced nutrient cycling.

Key words: *Rhizosphere, PGPR, RMPs, BMPs, NUE*

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ZERO TILLAGE WHEAT - AN IMPORTANT ALTERNATIVE FOR SUSTAINING LAND AND WATER PRODUCTIVITY IN MUZAFFARPUR DISTRICT OF NORTHERN BIHAR

Anupma Kumari, Anupam Adarsh and Nishi Keshari

Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar

Soil moisture conservation is key priority for improving land and water productivity in all agroclimatic condition. Sowing of wheat with zero till seed drill machine is a resource conservation technology being advocated to uplift water productivity, reduces soil erosion, improving soil health by building organic carbon status and reduces cost of cultivation. Extensive tillage with its high costs can be reduced by use of zero tillage with residue retention which is needed to ensure production sustainability. Similarly, the conserved soil moisture helps in reducing the water inputs without affecting the grain yield which further improve the declining water and land productivity.

Adoption of zero tillage technology by farmer in India has occurred mainly in the rice-wheat crop production system. In Bihar also it is emerged as a way to achieve enhanced productivity and profitability while protecting natural resource and environment. So for wide adoption of this technology Front Line Demonstrations (FLD) were conducted through KVK, Saraiya in different block of Muzaffarpur district from year 2017 to 2019 and finally result shown that yield and net return of wheat crop was higher with zero tillage technology than conventional tillage was 6% and 25% respectively due to reduction in operational cost. Similarly use of human labour and irrigation were saved by 14% and 16% respectively with zero tillage than conventional method of wheat production. The conserved soil moisture helps in reducing the water inputs without affecting the grain yield which further improved the declining water and land productivity. Zero tillage performs best compared to conventional under stressed conditions, delineating merit of zero tillage viz. enhanced water use efficiency when residue are retained.

Hence this technology is being disseminating in different villages of Muzaffarpur district of north Bihar as an important alternative for generating higher farm income and sustaining land and water productivity in resource starved regions of north Bihar. In Bihar this is one of the technology which help to escape the wheat crop from Terminal heat.

Key words: *Zero tillage, Conventional, water productivity*

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INTEGRATED FARMING SYSTEM IN INDIA: A HOLISTIC APPROACH FOR SUSTAINABLE YIELD AND ECONOMIC EFFICIENCY

Arshdeep Singh[1] and Shimpy Sakar*

[1]Department of Agronomy, M S Swaminathan School of Agriculture, Solan, Himachal Pradesh-173229, India (e-mail-arshdeep@shooliniuniversity.com)

**Department of Entomology, School of Agriculture, Lovely Professional University, Phagwara-144411, Punjab, India.*

**Corresponding author email: shimpy.23645@lpu.co.in*

In the present scenario, the population of India is increasing in a quick manner and we could not expand our production areas due to shrinkage in farm area. So, the challenge is to increase the production to feed the massive population. Conventional agriculture has caused economic problems associated with increased costs of energy-based inputs, reduced farm incomes etc. It has also responsible for ecological problems such as poor ecological diversity, soil erosion, and soil and water pollution. Monocropping is risky due to climate uncertainty as farmers invest more in single crop to get maximum return. The integrated farming system assumes greater importance to minimise the risk of monocropping and efficient management of farm resources to increase the farm productivity, reduce the environmental degradation and improve the quality of life for poor farmers and to maintain sustainability. Integrated farming system (IFS) is considered as one of the best option towards intensification of small holder farm income to ensure sustainable livelihood. Integration of resources is made through a combination of land, water and animal resources of a farm through careful planning including recycling of bio-resources. Integrated farming is a system which tries to imitate the nature's principle. In this system not only crops but, varied types of plants, animals, birds, fish and other aquatic flora and fauna are utilized for production. These are combined judiciously in such a way and proportion that each element helps the other. It ensures that wastes from one form of agriculture become a resource for another form. There are many models developed by researchers in different corners of our country but there is immense need of proper documentation and dissemination for the betterment of poor and prosperity of our country both in rural and urban sector. Therefore, it is high time for the promotion of IFS concept and knowledge in different agro-climatic pockets of our country to contribute towards national agenda-doubling the income of the farmers as well as addresses the issue of malnutrition.

Key words: *IFS, components, doubling income, conventional agriculture, mono-cropping*

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KULAGAR – A POTENTIAL HOMESTEAD FARMING SYSTEM IN KONKAN REGION

N.P. Singh and Basavashri Yadawad

ICAR-Central Coastal Agricultural Research Institute Ela, Old Goa - 403 402 North Goa India

Konkan region of India (Goa, parts of Maharashtra and Western parts of Karnataka) are blessed with the diversity of tropical flora and fauna due to the nearness to the Western Ghats. The hot humid climate and the presence of heavy monsoon have made this region a biodiversity hotspot with beautiful landscape. Konkan region farmers have a conventional homestead system of gardening transmitted from their ancestors called *Kulagar*. It is potential system to conserve the crop diversity and also an integrated system which includes cash crops, plantation crops, spices, fruits, local vegetables, medicinal

and aromatic plants and flower crops. The major crops found in *Kulagar* are arecanut, coconut, banana, and spices. Some of the *Kulagar* farmers have included complimentary enterprises such as dairy, poultry, goat farming etc. to increase farm profitability and income. The main objective of *Kulagar* is to meet out the food and nutritional requirement of the farm family and to generate year-round income. *Kulagar*system is also eco-friendly approaches for doubling farmer's income in which the residue generated in the system is recycled through mulching and composting. Natural springs/streams or wells act as a source of irrigation in *Kulagar*system andthrough technological interventions drip/sprinkler system of irrigation has becomepopular in the last decade. Adoption of *Kulagar* farming system approaches combined with allied innovative approaches plays vital role to meet the present day's challenges in agriculture. Scientific *Kulagar* farming will increase the crop and livestock production leading to regular and enhanced income to farmers. Advanced crop production technologies are being incorporated in *Kulagar* by the new generation farmers to make it sustainable and economically viable.

Key words: *Konkan, Goa, Kulagar*

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TEMPORAL FOREST COVER CHANGES IN CHAKRASHILA WILDLIFE SANCTUARY, ASSAM, INDIA USING REMOTE SENSING AND GIS

Devendra Kumar*, Sandeep Rawat, Mayank Joshi and Rajesh Joshi

G.B. Pant National Institute of Himalayan Environment (NIHE), Sikkim Regional Centre, Gangtok 737 101, Sikkim
**Corresponding author email: devendrawii@gmail.com*

The spatial and temporal forest cover changes over the last few decades in ChakrashilaWildlife Sanctuary (CWS), India were mapped using Landsat MSS, TM and ETM+ remotely sensed images. Field floristic survey were carried out to assess and classify the land use as well as different forest type classes on the basis of species composition i.e. semi-evergreen, moist-deciduous, dry-deciduous, degraded forest and water bodies using remote sensing (RS) and Geographical Information System (GIS). The satellite data analysis showed considerable changes in all forest types during the period 1978 to 2010. Present investigation indicates loss in forest area of 729 ha (16%) during the last three decades and subsequent changes in forest dynamics. The non-forest area, analyzed by vegetation indices viz., Normalized Difference Vegetation Index (NDVI), showed an increasing trend. Overall forests cover change analysis for last 33 years (1978-2010) in different forest types indicates gradual increase in the degraded forest area 644 ha (14%). The overall classification accuracy of 88.12, 92.98 and 95.66 percent were achieved for the year 1978, 1991 and 2010, respectively. The study reveals role of RS & GIS in monitoring the changes within forest cover, underlying changes due to illegal timber harvesting, forest clearance for agriculture practices, lopping, grazing, forest fire and invasion of exotic species which could be useful for management of forest resources.

Key words: *Chakrashila Wildlife Sanctuary (CWS), Forest cover, Forest types, Remote Sensing, Normalized Difference Vegetation Index (NDVI)*

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INTEGRATED NUTRIENT MANAGEMENT IN SUMMER GREEN GRAM (*Vigna radiata* L.)

G. J. Patel[1], A.Y. Makani[2] and H. K. Desai[3]

Tribal Research Cum Training Center, A.A.U.

With a view to study "Integrated nutrient management in summer green gram (*Vigna radiata* L.)" a field experiment was conducted during 2019 and 2020 at Tribal Research cum Training Centre, Anand Agricultural University, DevagadhBaria, Dist. Dahod, Gujarat. The soil of the experimental site was sandy loam in texture, free from any kind of salinity or sodicity hazards, having low in organic carbon and nitrogen, medium in available phosphorus and high in potassium.

The experiment consisted of 7 treatments with nutrient management through organic manure and inorganic fertilizer (T1:R.D.F@ (20:40:0::N:P_2O_5:K_2Okg ha^{-1}),T2:**0**4 t ha^{-1}FYM, T3:T2 +BioNP (5m/lkg seed,T4: 1t ha^{-1}vermicompost, T5: T4 +BioNP (5m/lkg seed T6: PROM (40kb P2O5 ha and T7:T6 +BioNP (5m/lkg seed). The experiment was laid out in randomized block design with four Replication. The greengram variety GAM53 in the experiment as a test crop. Significantly higher seed (1095 &1189 kg ha^{-1}) and haulm yield (1810 & 1861 kg ha^{-1}) were recorded under the application of T7: PROM (40kb P2O5 ha +BioNP followed by 100% R.D.F@ (20:40:0::N:P_2O_5:K_2Okg ha^{-1})over 4 t ha^{-1}FYM and 1 t ha^{-1}vermicompost. Application of T7: PROM (40kg P_2O_5 ha +Bio NP also significantly influenced the plant height (cm), number of branches $plant^{-1}$, dry matter accumulation (g $plant^{-1}$), CGR (g cm^{-2} day^{-1}), number of pods $plant^{-1}$, pod length (cm). It also significantly enhances the N, P, K content and uptake in seed and haulm as well as recorded significantly higher N, P status of soil after harvest and protein content of green gram seed.

From the above findings, it is concluded that under middle Gujarat condition PROM (40kb P2O5 ha +BioNP found to be better in terms of higher growth, yield, net realization and BCR. Green gram should be fertilized with R.D.F@ (20:40:0:: N:P_2O_5:K_2Okg ha^{-1}) and seed inoculated with Bio NP (*Rhizobium* + PSB) @ 5 ml kg^{-1}in summer season.

Key words: *Integrated farming system, PROM,Bio NP (Rhizobium + PSB)*

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CHANGES OF SOIL ORGANIC CARBON UNDER DIFFERENT MULCHING PRACTICES IN CITRUS ORCHARDS OF HILLY REGION

Hiren Das, N. Surbala Devi, Nakeertha Venu and T. Sanahanbi Devi

Department of Soil Science & Agricultural Chemistry
College of Agriculture, Central Agricultural University, Imphal, Manipur-795004
**Corresponding author email: thehirendas@gmail.com*

Soil erosion and the associated impact on the environment are made more severe by a lack of soil conservation practices. Soil erosion on sloping land can be reduced and soil organic carbon (SOC) content improved by selecting appropriate soil management methods in citrus orchards. Mulching practices have been proven to be effective in controlling soil erosion. Soil carbon fractions respond more quickly to environmental changes than total organic carbon, and therefore play an important role in dynamic change in soil condition. Understanding the character of SOC and labile C fractions, and their relationships with soil properties is vital for a better assessment of the effects of management on soil properties, nutrient

cycles, soil erosion, and C sequestration in citrus orchards of sloping arable land. Application of straw mulch and grass mulch causes dynamic changes in SOC and its fractions in soil. Compared to the soil without cover, mulching increases the contents of SOC. The contents of organic carbon and its active fractions decreased with increasing soildepth. SOC was accumulated in the period of December-March. Straw mulching had no significant effect on the changes in soil organic carbon active fractions during the different periods. Straw mulching had a significant effect on soil, increasing SOC content and stock in slope arable land, and that live grass mulching was more effective than rice straw mulching.

Key words: *Citrus, Soil erosion, Straw mulch, Grass mulch, Soil Organic Carbon*

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RESPONSE OF DIFFERENT ROW SPACING, PHOSPHOROUS AND BIOFERTILIZERS ON YIELD ATTRIBUTES OF HYBRID MAIZE (*Zea mays* L.)

Lipi Rina, Joy Dawson and *Manoj Kumar

Department of Agronomy, Naini Agricultural Institute,
Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Allahabad),
Uttar Pradesh - 211007, Uttar Pradesh, India

To study the effect of row spacing with different levels of Phosphorous and biofertilizer of maize", field experiments were conducted during *kharif* season of 2017 with 12 treatments replicated thrice in randomized block design at the Central Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology & Sciences Allahabad. The experiment consisted of row spacing (45 cm x 20 cm and 60 cm x 20 cm) three levels of phosphorous (60, 80 and 100 kg ha^{-1}) with inoculated with PSB and un inoculated. On the basis of research findings, it may be concluded that phosphorous at the rate of 80 kg P ha^{-1}, row spacing 60 cm x 20 cm with inoculated with PSB has the best performance for obtaining higher grain yield (5.22 t ha^{-1}), stover yield (6.90 t ha^{-1}), harvest index (43.13%), test weight (28.33 g) and other growth and yield attributes.

Key words: *Spacing, PSB, P rates*

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EFFECT OF FENCING AND LAND SLOPE POSITION ON SOIL CHEMICAL AND PHYSICAL CHARACTERISTICS OF DEGRADED LANDS IN AN AGRICULTURAL CATCHMENT

M.S. Hadda *and K.B. Thapa[1]

Department of Soil Science, Punjab Agriculture University, Ludhiana-141004
[1]Nepal Agriculture Research Council, Nepal
**Corresponding author email: ms_hadda@yahoo.com*

Land degradation is a serious problem due to several factors in the foothills of Shivalik's. Thus, it is of paramount concern to use soil conservation measures and practices along with barbed wire fence to manage the problem of land degradation by water erosion and compaction in the catchment. Keeping these points in view, an investigation was carried out in examining the effect of fencing and land slope position on soil chemical and physical characteristics of degraded lands in an agricultural catchment in the foothills of Shivalik. Thus, the present investigation was carried out at DR Bhumbla Zonal Research

Station for Kandi Area, Ballowal-Saunkhri in district SBS Nagar, Punjab. The main treatment comprises fenced and non- fenced and the sub-treatments (natural factor) include upper, middle, and lower land slope position and sub-sub treatments were soil depth that is 0-5, 5-10, 10-15 and 15-30 cm. The Factorial Randomized Design was followed and replicated thrice. However, the fencing was existing in the agricultural catchment for the last 15 years. The results of the investigation suggested the use of fencing with barbed wire along with soil conservation measures and practices offered better resilience as reflected through improved soil chemical (CEC, Organic C, Total N, available P and K) and physical characteristics (per cent proportion of sand and clay, better GMD, lowered D_b, improved Ks, MWHC, higher porosity and lowered penetration resistance) in the catchment. However, the individual effect of treatment (TR), land slope position (TS) and depth (DP) varied with respect to soil chemical and physical characteristics in the catchment. Similarly, the interactive effects of TR x DP, TR x TS and TR x TS x DP differed in their effect and magnitude on soil chemical vs-a-vis physical characteristics in the catchment.

Key words: *Soil parameters, Fencing, Undulating terrain*

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GROUND WATER VULNERABILITY ASSESSMENT

Mamatha Prabahakar[1*] and Sasikala, D.[2]

[1]PhD Scholar, Kelappaji College of Agricultural Engineering and Technology, Tavanur
[2]Professor & Head, Department of Irrigation and Drainage Engineering, Kelappaji College of Agricultural Engineering & Technology, Tavanur

In many parts of the world, where surface water supplies are scarce, domestic, agricultural, and industrial water needs can only be met by by means of the groundwater resources. Groundwater is the principal source of usable, fresh water in the world. During the last decades, intense agriculture activities and fertilizer applications have resulted in groundwater contamination, which has become a critical issue. In addition to agricultural activities, the release of municipal and industrial wastes has caused an increase in contaminants in the subsurface environment (Gheisari, 2017). Recently, groundwater vulnerability mapping is found to be an important key to decision-making and planningprocesses in order to prevent groundwater contamination (Mahvi*et al*. 2005). Groundwater vulnerability is the degree of protection that the natural environment provides against the spread of pollution in groundwater and it isclassified into intrinsic and specific vulnerability (National Research Council 1993). Vulnerability assessment to delineate areas that are more susceptible to contamination from anthropogenic sources has become an important element for sensible resource management and land use planning. Many approaches have been developed to evaluate aquifer vulnerability. These include overlay / index methods, process-based methods and statistical methods (Tesoriero*et al*., 1998). The process-based methods use simulation models to estimate the contaminant migration (Barbash and Resek, 1996). Statistical methods use statistics to determine associations between the spatial variables and the actual occurrence of pollutants in the groundwater. While the overlay / index methods use location specific vulnerability indices based on the factors controlling movement of pollutants from the ground surface to the saturated zone. Of these major approaches, the overlay/index method has been the most widely adopted approach for large scale aquifer sensitivity and ground water vulnerability assessments. DRASTIC (Aller *et al*., 1987) is the most commonly used overlay / index methods method and other method includes, SINTACS (Civita, 1994), GOD (Foster, 1987), AVI (Stempvoort*et al*.1993), EPIK (Doerfliger and Zwahlen, 1997), SI (Ribeiro, 2000) respectively. Saha and Alam (2014) estimated the vulnerability of groundwater in the southern part of the Gangetic plains in the state of Bihar, by application of DRASTIC and Pesticide DRASTIC models. A linear regression between groundwater NO_3 concentrations and the vulnerability

zonation revealed better correlation for Pesticide DRASTIC model, emphasising the effectiveness of the model in assessing groundwater vulnerability in the study region. The SINTACS model is the most extensively used method for identifying the areas where groundwater supplies are most vulnerable to contamination. Kumar *et al.* (2012) applied the SINTACS model for a part of Kancheepuram district, Tamil Nadu, India to generate a small-scale map of groundwater vulnerability to contamination. The whole area was classified as very low, low, moderate and high susceptibility to pollution. The model is validated with ground water quality data and results have shown strong relationship between SINTACS specific vulnerability index and nitrate-as-nitrogen concentrations.

Key words: *Groundwater vulnerability assessment- overlay / index methods- process-based methods-statistical methods*

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REVIEW ON SOIL MICROBIAL BIOMASS CARBON IN RECLAIMED COAL MINE SPOIL OF CHRONO-SEQUENCE SITES

Pankaj Maurya[1] and Reginald Ebhin Masto[2]

[1]Research Scholar, Environment, Emission and CRM, CSIR-Central Institute of Mining and Fuel Research, Dhanbad, [2]Principal Scientist & Head, Environment, Emission and CRM, CSIR-Central Institute of Mining and Fuel Research, Dhanbad

Soil microbial biomass carbon (SMBC) is a well-known indicator of ecosystem development in post mining land. Reclamation and re-vegetation of mine land helps in soil development which is reflected in terms of increased SMBC. Studies of successive soil development and the assessment of microbial biomass in mine land is limited.The amount of SMBC on mine land depends on the nature of the substrate, vegetation, environmental conditions, litter fall, management practices, etc. Complex interaction between vegetation, age of succession, and climatic factors are involved in soil development in mine land. This review is focussed to understand the progressive development of microbial biomass carbon in reclaimed mine land using different Chrono sequence studies.

Key words: *Soil microbial biomass carbon, Mine spoil, Reclamation, Chrono-sequence*

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CONSTRUCTION OF AN ELEVATED WATER HARVESTING STRUCTURE AS SOIL AND WATER CONSERVATION STRATEGY IN XINGLO MICRO WATERSHED

Shikha Rai, Prafull Katre and Jitendra Sinha

Department of Soil and Water Engineering, IGKV, Raipur

Soil and water both are the most precious gift of nature and it is essential to have proper soil and water conservation structures on watershed basis. Xigloo is part of a micro watershed on which this study is focused. Total area of the study micro watershed is 101 ha. Study area is surrounded by hills and having barren land on the periphery of hills followed by agricultural land. Micro- watershed was delineated for study using Google earth. For this study firstly survey and digital mapping was done which saves time and also improves the quality of the DEM and Contour maps. The GPS device was also used for easy location of points within the watershed. With the help of various GIS generated maps, it was easy to propose and locate the conservation measures and engineering structures in the study area for preventing erosion losses and to conserve water for future use. Using ArcGIS 10.5 with the Arc tool,

watershed delineation was performed. A Reconnaissance survey was carried out to collect original data about the study area's topographic. The drainage map shows that the total length of stream is 12.54 km and drainage density (12.5 km/km^2) of the watershed which indicates high flooding area. The study area topography is rugged, hilly and undulated, so the quantity of rainfall this region receives is going away in the form of high intensity runoff and almost all precipitation is drained away along the hills slopes. This runoff must be harvested for future use by storing it. Elevated water storage tank (Storage capacity of 79584.12 m^3) is designed and constructed in the study area to collect water coming from the hilly catchment area. The harvested water will be utilized for supplement irrigation to the nearby and downstream fields and also for livestock drinking. The well located in the downstream area will also be benefited due to continuous recharging. The cost of construction of an elevated water storage structure was estimated to be ¹ 3200000. It is designed on the basis of calculated runoff which comes out 2.7 m^3 / s for the catchment area of 10 ha it was estimated by using rational method. A Coffer dam was also proposed and constructed just besides the bank of tank to block the gullies carrying runoff water coming from the hilly catchment of the tank. It stops water, deposit silt, head up water so that silt free water enters the pond through designed inlet. Emergency spillway is also proposed on the coffer dam with the provision of gates. Emergency spillway allows peak coming from the catchment to be removed safely.

Key words: *Watershed, Runoff, Coffer dam*

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CLIMATE RESILIENT AGRICULTURE: ADOPTION AND STRATEGIES FOR SUSTAINABLE CROP PRODUCTION

Shivani Ranjan* and Sumit Sow

Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur-813210
**Corresponding author email: ranjanshivani54@gmail.com*

Climate variability and change has negative impact on food security and agricultural livelihoods of the small and marginal farmers, fishers and forest-dependent people. Climate change may be beneficial to agriculture, depending on geographical region. However, for the lower latitude areas, climate change is projected to result in increased temperature, reduced rainfall and increased frequency of extreme weather events such as floods and droughts. Climate Resilient Agriculture (CRA) is a relatively new approach that promotes sustainable increase in agricultural productivity and income, adapting and building resilience to climate change and reducing greenhouse gas emissions. CRA ideally has three pillars (i.e., adaptation, mitigation, and food production measures) to achieve food and nutrition security.Several CRA practices such as cropping system improvement (e.g. crop rotation, diversification, improved varieties and integration of legumes), integrated nutrient management (e.g. green manure, compost and site specific nutrient management), resource conservation (e.g. minimum/zero tillage, keeping the land consistently covered with crop residues), precision water management (e.g. planting crops in bed, laser land levelling, mulching with crop residues) and agro forestry have been proposed for adaptation to climate change and variability.CRA brings together practices, policies and institutions that are not necessarily new but are used in the context of climatic change which is prime requirement for sustainable production. Farmers possess low level of knowledge regarding climate change, and they should adopt CRA technologies to increase agricultural productivity without affecting the soil health as well as adaptive capacity at multiple levels (from farm to nation).

Key words: *Climate change, Climate resilient agriculture, Soil health*

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PROFITABILITY OF DIFFERENT TURF GRASSES INFLUENCED BY WEED MANAGEMENT AND METHOD OF ESTABLISHMENT

Sithin Mathew[1*], G. K. Seetharamu[2], B. C. Patil[1], M. Dileepkumar[1], S. B. Amruta[1], D. Satish[3] and S. Mukund[1]

[1]K. R. C College of Horticulture, Arabhavi- 591218, Karnataka, India
[2]College of Horticulture, Bengaluru- 560065, Karnataka, India
[3]College of Horticulture, Bagakot- 587104, Karnataka, India
**Corresponding author email: sithin.mathew.m@gmail.com*

The profit of turf (lawn) cultivation depends on method of establishment, maintenance and durability of grasses in the field. An experiment was conducted at KRCCH arabhavi, UHS Bagalkot to evaluate the profitability of lawn (turf grass) cultivation during 2018-2019. Grasses are marketed at 100 Rs. Per m^2 hence for 1-hectare area total gross income of Rs. 20,00,000 is obtained. Among the treatments highest benefit to cost ratio was obtained with chemical weeded plots which were planted with Mexican grass by seed sowing at 5g/m^2 (4.16) and net income of Rs. 1519759, followed by hand weeded plots which were planted with Mexican grass by seed sowing at 5g/m^2 (4.03 and net income Rs. 1503759). The cheaper availability of Mexican grass seeds and effective management of weeds by the soil fumigant Dizomet 98 MZ made the grass profitable compared to Bermuda grass. Whereas, lowest B:C ratio (2.72) was obtained with hand weeded plots planted with Bermuda grass var. 'Tif dwarf' by seed sowing method at 10 g/m^2 and net income of Rs.1265759, which made it less profitable due to the high cost of Bermuda grass seeds and increased labour cost for weed management.

Key words: *Mexican grass, Bermuda grass, B: C ratio, Net income*

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SOIL AND WATER MANAGEMENT PRACTICES FOR CLIMATE RESILIENT RAINFED AGRICULTURE

Sumit Sow* and Shivani Ranjan

Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur-813210
**Corresponding author email: sumitsow19@gmail.com*

Rainfed agriculture is likely to be more vulnerable to climate change in view of its high dependency on monsoon and the chances of increased extreme weather events like delayed onset of monsoon, high intensity rainfall, seasonal drought, early withdrawal of monsoon etc. due to aberrant behavior of south-west (SW) monsoon.Interventions like mulching with crop residues, in-situ moisture conservation, and protective irrigation from harvested rainwater in farm pondshelp to mitigate mid-season drought in various field crops. In-situ soil and water conservation (SWC) practices improve soil structure and soil porosity, increase infiltration and hydraulic conductivity, and consequently increases soil water storage that help crops to withstand moisture stress. There is a need to upscale these technologies through KVKs, ATMA and several national or state programmes of the government to cope up with weather aberration for productivity enhancements and large-scale impacts. Adoption of location specific soil and water management practices is both essential and a prerequisite to make rainfed farming more economical and sustainable under increasing frequency of droughts, decrease in number of rainy days, and extreme and untimely rainfall. Balanced nutrient application to crops based on the nutrient requirement to produce a unit quantity of yield and the native nutrient supplying capacity of soil improves crop yield while minimizing nutrient losses and cost of cultivation. There is sufficient scientific data to

suggest that productivity of rainfed agriculture can be enhanced significantly on a sustainable basis if two basic natural resources, i.e. soil and rainwater, are well managed. Therefore, conservation of soil and rainwater is an ideal strategyto reduce the vulnerability of the farming sector due to climatic variation.

Key words: *Climate change, Mulching, Rainfed agriculture, Soil pososity*

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EVALUATION OF DIFFERENT METHODS OF FERTILIZER RECOMMENDATIONS ON YIELD AND QUALITY OF RICE

Bagavathi Ammal U.*, Krithika C.*, Omar Hattab K.* and Pradip Dey**

**Department of Soil Science and Agrl. Chemistry*

PAJANCOA&RI, Karaikal-609 603, U.T. of Pondicherry, India.

***Project co-ordinator (STCR), Indian Institute of Soil Science, Bhopal- 462 038. MP, India*

Corresponding author email: pancham112@gmail.com

To validate the fertilizer prescription equation, a field experiment was conducted at farmer's field at Arachikuppam village, Puducherry with rice (white ponni). The soil of the experiment is classified under Sanyasikuppam soil series of *Fine-loamy mixed isohyperthermic typic ustropept*. The experiment consisted of ten treatments *viz*., blanket recommendation, STCR-NPK alone for 6, 7 and 8 t ha^{-1} yield targets, STCR-IPNS for 6, 7 and 8 t ha^{-1} yield targets, farmer's practice, FYM alone and absolute control in RBD with three replication.

Fertiliser Prescription Equation

FN : 3.75 T – 0.52 SN – 0.59 ON

FP_2O_5 :1.53 T – 1.24 SP - 1.77 OP

FK_2O : 1.58 T – 0.33 SK - 0.93 OK

The grain yield of the test verification trial on rice revealed that , the yield ranged from 2.63 t ha^{-1} in control to 8.12 t ha^{-1} in STCR-IPNS- 8 t ha^{-1}.With regard to STCR-NPK alone treatments for the targets of 6 , 7 and 8 t ha^{-1}, the yield recorded were 5.73 ,6.68 and 7.84 t ha^{-1} respectively. Under STCR-IPNS, the yield obtained were 6.01, 7.00 and 8.12 t ha^{-1} respectively. The farmer's practice recorded the yield of 4.81 t ha^{-1} but it was higher than blanket recommendation (4.27 t ha^{-1}).The results have clearly broughtout the fact that STCR treatments recorded significantly higher grain yield over both recommendation and farmer's practice. The highest achievement of the yield targets was recorded with STCR-IPNS 8 t ha^{-1} (101.5 %) followed by STCR - IPNS – 6 and 7 t ha^{-1} (100.0 %), STCR - NPK alone- 8 t ha^{-1} (98.0 %) and STCR - NPK alone – 6 and 7 t ha^{-1} (95.4 %) .The results revealed that, the percent achievement of the targeted yields were within +/- 10 percent variation, which has proved the validity of the fertilizer prescribing integrated fertilizer doses for rice.The RR recorded for various treatments ranged from 10.6 kg kg^{-1} in farmers practice to 25.9 kg kg^{-1} in STCR -IPNS –7 t ha^{-1} .Among the STCR treatments , IPNS recorded relatively higher RR than NPK alone treatments. Blanket recommendation recorded 6.5 kg $kg^{-1,}$ which is lower than all the STCR treatments. Higher crude protein contents were recorded in all STCR methods of fertilizer recommendations through organic and inorganic combinations, ranging from 8.39 % to 9.00 %. The lowest crude fibre (8.00 %) was recorded in STCR method through inorganic and organic for 8 t ha^{-1}. Higher starch content was recorded by STCR recommendation through inorganic and organic for 8 t ha^{-1}(77.20%), which was closely followed by the same method through inorganic and organic for 7 t ha^{-1}(75.47 %).

Key words: *STCR, Fertilizer recommendations, Crude protein*

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LOW COST NATURAL FARMING: A STEP TOWARDS ATMANIRBHAR BHARAT

Y.B. Vala[1*] and C.K. Patel[1]

Department of Agronomy, C. P. College of Agriculture, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar-388 506, Gujarat

**Corresponding author email: yashrajsinhvalaagri8877@gmail.com*

In India, the agriculture sector has been dominated for the past over 40 years by Green Revolution. Now a days using conventional techniques in agriculture is like cancer to our soil and health as well. It does not only make the soil barren but eventually, the farmers goes under debt. A revolutionary impact of green revolution or modern agricultural techniques that broke away the old and outdated traditional practices. Green revolution has left bad footprints on country's food security and environmental safety. Hence, the only way to deal with this ever rising problem is Low Cost Natural Farming (LCNF). Low Cost Natural Farming is one such low-input, climate-resilient farming that inspires farmers to use low-cost and locally-sourced and available inputs, eliminating the use of artificial/chemical fertilizers and industrial pesticides. The word 'cost' refers to credit and expenses, and the word 'low' refers to minimum thus the phrase 'low cost' meanswith the use of minimum to minimum or nil credit, and without spending any extra money on purchased inputs. All inputs are to be locally resourced from the farms or around the village. 'Natural farming' means farming with Nature based and without chemicals and fertilizers. Low Cost Natural Farmingis a set of farming methods, and also a grassroots peasant movement, which has spread to various states in India. Low Cost Natural Farming use mulching, soil protection techniques, crop rotation, green manures and natural pesticides. There are most popular four pillars of LCNF i.e. *Jeevamrut, Beejamrut, Acchadan*and*Whapasa.* Natural product made from farm resources utilized for nutrition, food safety, food security and plant protection purpose which helps the farmers to find other alternative method of natural farming especially for their self-reliance (Atmanirbhar).

Key words: *Low Cost Natural Farming (LCNF), Green Revolution, agriculture, Farmers, Food safety, Food security, Natural Farming, Atmanirbhar*

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INFLUENCE OF COCONUT HUSK BIOCHAR ON SOIL PROPERTIES AND SOC STOCK IN THE NORTH CENTRAL LATERITES OF KERALA

R. Rajakumar[1*], S. Jayasree Sankar[2] and U. Bagavathi Ammal[1]

[1]*Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal – 609 603, Puducherry U.T., India*

[2]*College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur – 680 656, Kerala, India*

**Corresponding author email: letter4rajakumar@gmail.com*

An investigation was carried out to explore the potential benefits of coconut husk biochar on the selected soil properties and SOC stock in the north central laterites of Kerala (AEU 10). Two field experiments were carried out continuously, wherein Chinese potato was raised to study the direct effect and cowpea was the test crop to study the residual effect of coconut husk biochar on soil properties. Three levels of coconut husk biochar (5, 7.5 and 10 t ha^{-1}), FYM 10 t ha^{-1}, soil test based POP with and without biochar and absolute control were the treatments. While the soil properties such as pH, electrical conductivity, organic carbon, and dehydrogenase activity was estimated after each crop, all other soil properties were measured only after two crops. Results showed that the soil bulk density was significantly reduced by application of biochar 10 t ha^{-1} and soil test based POP + biochar (1.23 Mg m^{-3}). Application of biochar 10 t ha^{-1} either alone or in combination with POP showed a superior effect on porosity, WHC,

dehydrogenase activity, organic carbon and SOC stock. With respect to pH, significant improvement was noticed with application of 10 t biochar ha^{-1}. Application of biochar at higher dose (7.5 and 10 t ha^{-1}) and soil test based POP + biochar 10 t ha^{-1} were comparable and superior in terms of CEC and fractions of organic matter. Improvement in soil properties synchronized well with the increase in biochar application rate. Thus, it is clear that application of biochar could improve the soil quality and C storage in soil. Unlike the commonly used organic manures that get degraded and decomposed rapidly under tropical conditions, biochar with its strong residual effect and recalcitrant nature could prolong the sequestration of carbon, as evidenced from this study.

Key words: *Biochar, lateritic soils, soil properties, organic amendments, carbon stock*

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SUSTAINING PRODUCTIVITY OF CHINESE POTATO-COWPEA BASED CROPPING SEQUENCE THROUGH BIOCHAR IN LATERITIC SOILS OF KERALA

R. Rajakumar[1*], S. Jayasree Sankar[2] and U. Bagavathi Ammal[1]

[1]*Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal – 609 603, Puducherry U.T., India*

[2]*College of Agriculture, Vellanikkara, Kerala Agricultural University, Thrissur – 680 656, Kerala, India*

**Corresponding author email: letter4rajakumar@gmail.com*

Laterite and lateritic soils (Ultisol) cover nearly 65 per cent of the total geographical area of Kerala, occupying the midland and mid upland regions. These soils are generally acidic, low in CEC and BSP, poor in inherent fertility and high in P fixation. The compact B horizon that inhibits root penetration, reduced soil volume, low level of organic matter, decreased moisture retention are the major constraints to crop production which can be overcome through the application of manures, fertilizers and liming materials. Soil compaction and high rate of mineralization under tropical situation necessitates the continuous application of organic manures and amendments. It is in this context that 'biochar' which is an amendment highly resistant to decomposition serves as a viable proposition. In order to unwind the probable effect of the biochar on yield promotion, two field experiments were carried out sequentially in a soil belonging to Velappaya series and Fine loamy kaolinitic, isohyperthermic, Typic plinthustults as per USDA classification. Three levels of biochar (5, 7.5, 10 t/ha), FYM 10 t/ha, soil test based POP + biochar 10 t/ha, soil test based POP and absolute control were the treatments. Soil test based POP consisted of NPK recommendation for Chinese potato + FYM 10 t/ha. Plant height, average tuber girth, DMP, yield per plant and tuber yield were accounted towards interpreting the direct effect of biochar on Chinese potato. The treatment soil test based POP recorded the highest values for plant height (72.66 cm), average tuber girth (3.37 cm) and DMP (2959.3 kg/ha) which was comparable with soil test based POP + biochar. Whereas, in terms of per plant yield and tuber yield per hectare the treatment soil test based POP + biochar registered the highest values of 147.98 g and 24.04 t/ha as against the control values of 58.79 g and 16.62 t/ha, respectively. For quantifying the residual effect of biochar on cowpea, the growth components like plant height, number of pods per plant and DMP and pod yield were recorded. The data showed that the same treatment soil test based POP + biochar that faired in terms of direct effect proved good in bringing out the residual effect as well, as reflected from the plant height (39.74 cm), pod length (15.27 cm), number of pods per plant (14.17), DMP (1463.5 kg/ha) and pod yield (6.624 t/ha). The study revealed the potential of biochar as an amendment in the highly weathered, nutrient-poor acidic laterite soils of the tropics. The overall improvement in physical, chemical and biological soil conditions through biochar sustained the plant growth and yield, as evidenced from the residual crop.

Key words: *Laterites, biochar, crop productivity, residual effect, growth parameters*

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EFFECT OF ZINC ON YIELD AND UPTAKE OF NITROGEN AND ZINC BY WHEAT

Suman Sharma* and Devashish Singh

Department of Botany, MGKVP, Varanasi-221005 (U.P.) India
**Corresponding author email: sumansharma.bio@gmail.com*

The interaction of nitrogen and zinc has a positive effect on the soil and plant systems by increasing nutrient availability in the soil and absorption by the plant. So it is preferable to add both nutrients together to raise the efficiency of their use to obtain the highest plant yield without loss large amounts of fertilizer used as well as reduce the cost. The interaction of nitrogen and zinc was one of the aspects that had a considerable attention in recent studies. It was a positive interaction occurred into soil and plant systems, its importance was due to increasing availability of both nutrients in the soil and absorbing by the plant, then increasing the bio-physiological activities which contribute to increasing plant growth, yield, and improving the yield quality as well as raising the use efficiency of both fertilizers, when be added together. In the plant system, nitrogen increased the plant uptake of zinc by increasing plant response to zinc, which contributed to increasing plant resistance to zinc deficiency or increasing zinc efficiency as well as adding nitrogen led to increasing dilution factor of plant zinc content to increase the growth as soon as adding nitrogen which led to increasing uptake of zinc. The nitrogen had a role in increasing the zinc content in the leaves and stems through promoting transmitting and movement of zinc, from the root to shoot system of the plant. The effect of zinc on the interaction was also positive due to its role in the bio-physiological processes within the plant. Zinc had a responsibility of nitrogen metabolic processes, entering in amino acids (lysine and tryptophan) formation, contribution to the formation of nucleic acids and large number of enzymes such as those responsible to protein formation. It had been found that the zinc deficiency resulted in protein metabolism decrement. The results found a positive effect of the nitrogen and zinc interaction on the growth and yield of various crops such as wheat and sunflower, also they indicated that adding the both nutrients together contributed to raising the efficiency use of both fertilizers.

Key words: *Interaction, N, Zn, Use efficiency, Plant uptake*

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INFLUENCE OF STCR-IPNS ON QUALITY PARAMETERS OF BHENDI [*Abelmoschus esculentus* (L.) Monech]

U.Bagavathi ammal*., V R .Maheshen*., R. Sankar[*]., K. Coumaravel and Pradip dey[**]

**Department of Soil Science and Agrl. Chemistry*
PAJANCOA&RI, Karaikal-609 603, U.T. of Pondicherry, India.
[**] Project co-ordinator (STCR), Indian Institute of Soil science, Bhopal- 462 038.MP, India
Email: pancham112@gmail.com.

To investigate the effect of different levels of NPK and STCR-IPNS treatments on quality of Bhendi fruit, a field experiment was conducted in Karikalampakkam village in Nettapakkam commune of Pondicherry district, U.T of Puducherry. The soil of the experimental field belongs to fine, mixed, isohyperthermic, *Typic Ustropept*. The experiment consisted of ten treatments *viz*., blanket recommendation, STCR-NPK alone for 160, 170 and 180 q ha^{-1} Bhendi yield targets, STCR-IPNS for 160, 170 and 180 q ha^{-1} yield targets, farmer's practice , FYM alone and absolute control in RBD with three

replication. Representative fruits were collected from tagged plants at 5th, 9th and 12th picking and used for estimation of quality parameters.

The content of mucilage was found to be the highest in plot which received FYM (12.5 t ha^{-1}) alone treatment (4.65 percent), which was comparable with STCR+IPNS treatments, farmer's practice and blanket recommendation treatments. The simple correlation had revealed that the mucilage content was positively related to fruit length (r = 0.648*), fruit girth (r = 0.671*), starch (r = 0.826**), protein (r = 0.899**) and ascorbic acid (r = 0.939**) and negatively correlated to crude fibre (r = -0.820**) at 19th picking. The starch content of the fresh fruit was higher in STCR+IPNS treatments which was comparable with blanket recommendation and FYM (12.5 t ha^{-1}) alone treatments. The multiple regression analysis had shown that the starch content was significantly correlated with all the soil properties at all the stages of picking.

The contribution being 84.7, 87.3 and 85.2 percent by pH, EC and organic carbon, 89.8, 89.1 and 88.1 percent by available nutrients and 98.9, 99.5 and 97.3 percent by P and K fractions at 5th, 12th and 19th picking respectively.The protein content of fresh fruit was numerically higher (1.84 percent) in the plot which received STCR + IPNS - 180 qha^{-1} treatment. The content of crude fibre was significantly higher in the fruits harvested in the control plot (15.63 percent) followed by STCR-NPK alone treatment and least in the plots which received STCR+IPNS treatments followed by FYM (12.5 t ha^{-1}) alone treatment. The maximum ascorbic acid content was found at 12th picking (12.97 mg 100g) which was comparable with 19th picking (12.85 mg 100g) and both were significantly different from 5th picking.

The yield targets of STCR-IPNS for 180 q ha^{-1} of bhendi proved their superiority over all other treatments in terms of quality parameters *viz*., mucilage (4.54%), starch (4.95), protein (1.84%), crude fibre (10.36%) and ascorbic content (13.99 mg/100 g). These treatments had recorded a yield increase of 11.35 and 32.96 per cent respectively over blanket and farmer's practice for Bhendi.

Key words: *STCR-IPNS, NPK, Ascorbic Acid, Bhendi*

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TRANSFORMATION OF IN SITU LINE SOURCE FIELD DRIPPER METHOD TO POINT SOURCE FIELD DRIPPER METHOD FOR ESTIMATING GARDENERS UNSATURATED HYDRAULIC CONDUCTIVITY FUNCTION FOR FIELD APPLICATION

Shubham Ojha[1], Chhedi Lal Verma[2], Derric M. Denis[3] and Sanjay Arora[4]

[1]M.Tech Research Scholar & [3]Professor and Head SHUATS Allahabad, [2&4]Senior Scientist and Principal Scientist at ICAR-CSSRI Regional Research Station, Lucknow

Unsaturated hydraulic conductivity function (UHCF) is an important soil physical parameter governing flow of water within the soil matrices. It depends on volumetric moisture content of soil and highly non linear covering entire range of soil moisture content and conductivity. Large numbers of UHCF had been reported in literature such as Gardner, 1958; Maulem, 1976; Van Genuchten, 1980; Brook and Corey, 1964; Singh and Verma, 2010a, b). UHCF is useful for describing unsaturated flow of water in the porous media, hence could be useful for designing of groundwater recharge system, subsurface drainage with evaporation and plant extraction of water from soil and conventional as well as advance irrigation systems namely drip and sprinkler. Richard (1931) developed highly non linear partial differential equation for assessing movement of water in unsaturated soil which is quite difficult to approximate as it does not have an analytical solution unless linearized. UHCF of Gardner (1958) had

been used successfully for linerizaton of Richard equation and obtained its analytical and numerical solution for various boundary conditions. Gardener's UHCF covers entire range of hydraulic conductivity against practical range of soil moisture variations in the soil. Many field methods had been suggested by the researchers for measuring UHCF of soil. Presently available field methods generally have three major difficulties associated with them: (i) Requirement of large volume of water to characterize a small area, (ii) long measurement time, and (iii) high labor requirement to account for spatial variability. Pressure plate apparatus is well accepted method for characterizing UHCF with changing soil moisture regime but it uses small disturbed soil sample. A bore hole test by means of a Guelph permeameter is widely discussed in-situ method for characterizing subsurface UHCF. The method is unreliable and gives physically impossible values of soil parameter of interest. Shani et al. (1987) proposed a field dripper method using Wooding's (1968) theory of pooled water for estimation of Gardener's UHCF. Ojha et al. (2020) proposed a more reliable line source field dripper method for estimation of UHCF of Gardner. Present study transformed the line source field dripper method to a simple point source field dripper method for estimating UHCF of the soil by introducing a correction factor (2/5*ð) for saturated conductivity and another correction factor (7/4* ð) for relative measure of capillarity over gravity. The transformed model predicted quite close UHCF in the fields and recommended for field application.

Key words: *Advance irrigation, Porous media, Unsaturated Hydraulic Function, Unsaturated flow.*

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MORPHOMETRIC ANALYSIS OF NUH WATERSHED, HARYANA, INDIA

Smita Jaiswal

Ph.D. Research Scholar, Discipline of Water Science and Technology, ICAR- Indian Agricultural Research Institute (IARI), Pusa Campus, New Delhi 110012
Smita11360iari@gmail.com

Remote sensing and GIS techniques are being extensively used since quite some time in watershed related studies as very effective tools in determination of the basin geometry i.e., morphometric analysis or quantitative description of watershed morphologic characteristics. In the present study, an attempt has been made to use the capabilities of R.S and GIS to quantify the morphology of the Nuh watershed using (ArcGIS 10.8) software. The watershed was studied for its size and shape, drainage and relief characteristics to develop a thorough understanding of the watershed for future planning to avert the land degradation. Twenty one morphometric parameters of the Nuh watersheds situated in Nuh block of Mewat District (Haryana) have been quantified. They comprise: Stream Order, Stream Length (Lu), Mean stream length (Lsm), Stream Length ratio (RL), Bifurcation ratio (Rb), Mean bifurcation ratio (Rbm), Drainage Density (Dd), Length of overland flow (Lg), Basin length (Lb), Basin perimeter (P), Basin/drainage area (A), Compactness constant (Cc), Stream frequency (Fs), Circulatory ratio (Rc), Elongation ratio (Re), Form Factor (Rf), Watershed shape factor (Ws), Drainage Texture (Rt), Total relief (H), Relief ratio (Rh), Relative relief (Rp) and Ruggedness number (Rn). On the basis of the morphometric studies it was concluded that the hydrologic response of the Nuh watershed is dependent on surface characteristics significantly due to its being a "Fan Shaped" one. The watershed is in active stage of degradation. Its quantification is being done based on the field measurements and recording of soil erosion. The result suggests that the ratio between cumulative stream length and stream order is constant throughout the successive orders of the basin.

Key words: *Morphometric analysis, GIS, Nuh watershed, Remote Sensing and Watershed Planning*

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EFFECT OF VERMICOMPOST SCHEDULING ON SOIL PROPERTIES, GROWTH PERFORMANCE OF RICE CROP AND ITS RESIDUAL EFFECT ON WHEAT CROP

Amit Kumar and B.P. Dhyani

Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut

A field experiment was conducted during 2011-12 and 2012-13 at CRC of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. Soil of experimental site was low in organic carbon, available nitrogen, medium in available phosphorus and potassium with slightly alkaline pH. Ten different treatments comprising application of different levels of vermicompost alongwith with different levels of nitrogen and recommended level of PK were tested in a randomized block design with three replications. Rice variety PB-1 and wheat PBW-502 were grown during kharif and rabi seasons of both the years. Observations on different growth parameters, yield and yield attributing characters, nutrient content, nutrient assimilation and physico chemical properties of soil at different growth stages of rice-wheat cropping system were recorded. Data were subjected to statistical analysis on which basis treatments effect were explained. The results reveal that growth parameters and yield attributing characters of rice crop were higher with application of 100% NPK (T2) through chemical fertilizer followed by T3 where along with 75% N 100% PK basal application of 2 ton vermicompost was made. Grain yield was also higher in T2 but it did not differ significantly from T3, T4 and T5. Plant nutrient content and uptake was also higher in T2 at different growth stages of rice. The nutrients availability in soil was affected by the timing of vermicompost application. Organic carbon, pH and electrical conductivity of soil at different growth stages of rice remained unaffected due to application of different treatments. The residual effect of preceding rice crop treatments on number of tillers per meter row length of wheat, spike length and test weight was non-significant while a significant residual effect was found on nutrients availability. The residual effect of 4 ton vermicompost application on grain yield of wheat was significant but application of 2 ton vermicompost could not result any significant effect. Percent organic carbon, soil pH, electrical conductivity remain unaffected due to residual effect while a significant effect was noticed on the bulk density of soil after wheat harvest. It is concluded that 25% nitrogen requirement of basmati rice can be supplemented through the application of 2 ton vermicompost ha^{-1} as basal, or at panicle initiation or at flowering stages of rice crop.

Key words: *Soil organic carbon, available nitrogen, Vermicompost, Rice*

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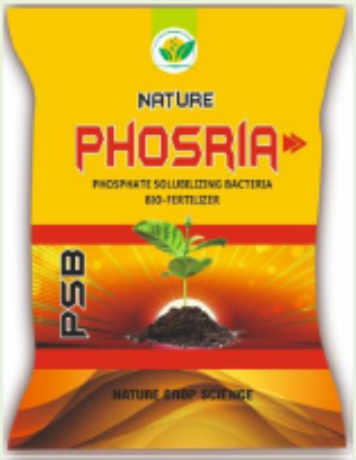

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बूंद–बूंद सिंचाई के लाभ

- उपज में वृद्धि
- एक समान वृद्धि
- अंकुरण दर में वृद्धि
- पानी की बचत
- खाद में बचत
- मजदूरी खर्च में बचत
- ईंधन की बचत
- कम उपजाऊ जमीन पर भी अच्छी उपज
- मिट्टी का उर्वरता बनी रहेगी

बूंद–बूंद सिंचाई :

बूंद–बूंद सिंचाई एक उत्पादक प्रणाली है जो पानी, उर्वरक, सूक्ष्म पोषक तत्वों एवं रसायनों को पौधों के जड़ तक पहुंचाता है।

- उचित स्थान पर
- उचित मात्रा में
- उचित समय पर
- उचित अंतराल पर
- उच्च क्षमता, उच्च गुणवत्ता एवं एकरुपता के साथ

बूंद–बूंद सिंचाई

अधिक उपज | कम लागत | आय दुगना

बूंद–बूंद सिंचाई प्रणाली कैसे कार्य करता है?

- कम मात्रा में पानी का उपयोग
- लगातार सिंचाई प्रतिदिन या दिन में कई बार
- निम्न दबाव का संचालन 7–15 पी.एस.आई.
- पौधों के जड़ के पास के मिट्टी को गीला रखता है
- बूंद–बूंद सिंचाई प्रणाली द्वारा पोषक तत्वों का उपयोग
- अधिक क्षमता एवं संभावित एकरुपता

बूंद–बूंद सिंचाई प्रणाली आम सिंचाई प्रणाली से कैसे भिन्न है।

1. प्रवाह सिंचाई प्रणाली में पानी पिस्टन की तरह मिट्टी के अन्दर प्रवेश कर जाता है और हवा एवं पोषक तत्वों को पौधों के जड़ से दूर बहा देता है।
2. बूंद–बूंद सिंचाई प्रणाली में पानी कम मात्रा में प्याज के आकार में मिट्टी के अन्दर धीरे–धीरे प्रवेश करता है और हवा एवं पोषक तत्वों को पौधों के जड़ के नजदीक रखता है।

फव्वारा सिंचाई


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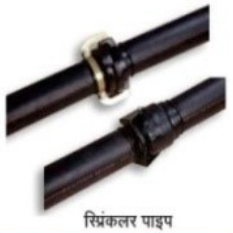
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फव्वारा सिंचाई के फायदे

- सिंचाई के परम्परागत तरीकों के मुकाबले इस विधि से सिंचाई करने पर मात्र 50–70 प्रतिशत पानी की आवश्यकता होती है।
- जमीन को समतल करने की जरुरत नहीं होती। ऊंचे–नीचे और मुश्किल माने जाने वाले भू–भागों में भी खेती की जा सकती है।
- बजाय इस बात के इंतजार में बैठे रहने के कि स्वाभाविक वर्षा या फिर सतही सिंचाई के बाद जमीन ठीक से नम हो तो जुताई की जाए, फव्वारा पद्धति से उचित समय पर जुताई और पौध रोपाई का काम किया जा सकता है।
- पाले और अत्यधिक गर्मी से फसल की गुणवत्ता कम जो जाती है। इस सिंचाई से फसल को बचाया जा सकता है।
- पौधों की रक्षा पर होने वाला खर्च कम हो जाता है क्योंकि कीड़े–मकोड़े और बीमारियां जैसी समस्याएँ कम पैदा होती हैं। छिड़काव की पद्धति के जरिए कीटनाशकों अथवा पौधों को पौष्टिकता देने वाली दवाएं बेहतर ढंग से छिड़की जा सकती है।
- फव्वारा के जरिए की जाने वाली सिंचाई का लाभ लगभग हर किस्म की फसल को पहुँचाया जा सकता है।
- नालियों या बांध बनाने की जरुरत नहीं पड़ती जिससे खेती के लिए ज्यादा जमीन उपलब्ध हो जाती है।
- इस विधि के द्वारा घुलनशील खाद भी लगाई जा सकती है, जिससे खाद की बचत होती है।

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