Academy of Natural Resource Conservation and Management (ANRCM), Lucknow

Proceedings cum Abstract eBook

National Web-Conference

Technological Approaches for Resource Conservation and Management for Environmental Sustainability

16-17 August, 2020

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NATIONAL WEB-CONFERENCE

ON

Technological Approaches for Resource Conservation and Management for Environmental Sustainability

August 16-17, 2020

PROCEEDINGS CUM ABSTRACT E-BOOK

Organzied by

Academy of Natural Resource Conservation and Management (ANRCM)
Lucknow, Uttar Pradesh

www.anrcm.org

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Citation: In: Sharma, V., Pareek, N.K., Sharma, N., Ojha, R.P., Arora, S. and Singh, A.K. (Eds.) **Proceedings cum abstract e-book,** National Web-Conference on Technological Approaches for Resource Conservation and Management for Environmental Sustainability, Academy of Natural Resource Conservation and Management, August 16-17, 2020, Lucknow (U.P.), p 263.

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Note: Responsibility for the information in the publication rests with the individual authors

Published by:

Secretary,

ANRCM, Lucknow

Organized by:

Academy of Natural Resource Conservation and Management (ANRCM)

#3/35 Virat Khand,

Gomti Nagar, Lucknow, Uttar Pradesh

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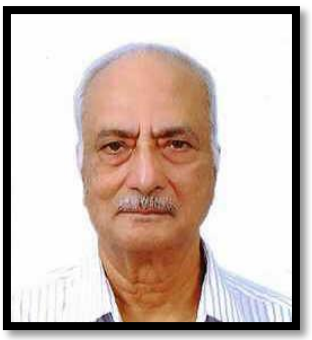

Dr. G.B. Singh
Ex-DDG (NRM), ICAR &
Vice-Chancellor, JNKVV, Jabalpur
Chief Patron, ANRCM
Lucknow (U.P.)

Inaugural Address

Good morning everyone. During the Covid-19 pandemic the world is facing the greatest ever challenge for human health. I am sure you and your family are safe and making every effort to Stay Safe and healthy. You might have witnessed during the present pandemic situation, everyone was concerned for food and food products may be bread, vegetables, fruits and milk that shows the importance of land from where all these are produced.

I am happy to be here at the inaugural session of the National Web- Conference on "Technological Approaches for Resource Conservation and Management for Environmental Sustainability" organized by Academy of Natural Resource Conservation and Management.

As you all are aware that 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.

During last few decades, over exploitation of natural resources has led to degradation and changes in the climate. We can observe frequent droughts, floods and many other natural disasters in recent years. Presently land degradation in India is to the extent of 104.2 mha which comprise 74.21 mha by Soil erosion, 6.73 mha by soil salinity and 10.72 mha by soil acidity. About 32-84% of ground water used for irrigation is either saline or brackish. These all have affected crop

productivity and thus their management is imperative for meeting food, nutritional end environmental sustainability.

Climate resilient agriculture will essentially involve judicious and improved management of natural resources, namely land, water, soil and genetic resources through adoption of best practices, appropriately integrated and timely management of farming systems and farm mechanization.

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.

Strategies also need to be developed to double the farmers' income as per the initiatives of Indian Government through judicious use of natural resources as well as agricultural inputs, adoption of improved techniques and ensuring sustainability of the agricultural production.

In this context, a National Web-conference dedicated for discussing issues, challenges and framing strategies for Resource management that is being organized today by Academy of Natural Resource Conservation and Management is very timely. I believe that the efforts made by Academy of Natural Resource Conservation and Management to organize National Web-conference will surely bring out plan for efficient management of natural resources through advanced technologies vis-à-vis mitigating climate change effects and uplifting farmers income.

I am sure that the experts, scientists, academicians, researchers and students participating in the Web-Conference will deliberate on various issues, discuss various options, experiences and come out with some recommendations for Conservation and Management of Resources to Improve Productivity, Biodiversity and Livelihood Security.

I extend my warm wishes to the learned speakers and participants as well as the organizing team of this Conference.

Thank You, Jai Hind

Stay Safe and Healthy

Dr Sanjay Arora
Secretary, ANRCM

About ANRCM

The Academy of Natural Resource conservation and management was established in Lucknow formed by a group of professionals, scientists, conservationists, researchers, students, farmers and all those who pledge to work for the wise use and management of precious finite and limited natural resources.

The Academy is a non-profit making organization devoted for the cause of conservation, development, management and sustainable use of resources like water, soil, land, forest and environment.

The Academy is mandated to take up activities like generating awareness, sharing and disseminating knowledge and advanced techniques and approaches for conservation and management of resources. In this endeavor, we planned to organize National Seminar during March 2020 and we got overwhelming response from participants all over the country but we could not accomplish it due to Covid-19 pandemic and we will be hosting it as soon the situation improves.

Also, taking the opportunity of World Population Day, the National webinar was organized on July 11 2020 with the Theme: Impact of Population Pressure on Natural Resources and Environment through video-conferencing.

The Academy intends for half-yearly e-Journal "Journal of Natural Resource Conservation and Management" and to publish bulletins on various themes of NRCM as well Newsletter, books and other useful study material for young professionals and students.

I on behalf of ANRCM convey my gratitude to the distinguished and renowned speakers who have agreed to our request to deliver talk in the National Webinar and thankful for the blessings of our Chief patron Dr. G.B. Singh and Patron Dr D.K. Sharma and the efforts made by Executive council of ANRCM specially Organizing team.

I am delighted to inform that we have received overwhelming response from participants and more than 458 participants. However, we could not accommodate all due to limitation of video-conferencing facilities. We shall be sharing this web-conference video on Youtube and other social networks including the official website www.anrcm.org and facebook.

During this two days National Conference there will be an Awareness on-line quiz for participants on August 17, 2020 for which the link will be sent on their emails as well as displayed in chat box on second day of conference. The link will be open for 30 minutes and the winners will be awarded e-certificates.

I hope the participants will surely be enlighten by the talks from the experts and will share knowledge during these two days of web-conference.

Dr. Vikas Sharma
Prof. & Head, Soil Science
SKUAST-Jammu
& Organizing Secretary

About the Web-Conference

It gives me immense pleasure to be among you and share our view at Academy of Natural Resource Conservation and Management (ANRCM), about the need to have a web-conference on resource conservation in these trying times.

The theme of the conference is aptly chosen as 'Resource Conservation and Management for Environmental Sustainability". Agriculture and Environment are intrinsically linked. However, we either have conferences on Agricultural related themes or Environmental issues. Though, we have been talking about the sustainability of agricultural production systems for a long.

Sustainability of agricultural production systems means the sustainability of environment around us in which the farmers practice their agriculture. Agriculture contributes significantly to environmental issues, be it emissions of methane from paddy fields or release of nitrous oxide from over use of nitrogenous fertilizers to contamination and eutrophication of water bodies. Vast chunks of arable land degrades every year due to improper agricultural practices, leading to further encroachment of natural forest lands around the globe. Increasing temperatures and Changing rainfall patterns are throwing new challenges every day.

Proper management of resources holds the key to sustainable eco-systems.

The conference, therefore, begins with a focus on environmental conservation and restoration of ecological balance and will go on to discuss the issues and options in soil and water resources conservation, soil health, organic farming and nutrient management. With agriculture both being a contributor to climate change and adversely affected by it, a dedicated session on climate smart approaches is also being held.

Resource conservation does not only mean protecting the environment but here in also lies the goal of enhancing economic returns for the stakeholders. We have noticed that poverty is the primary driver of eco-system degradation in developing and under-developed countries. For instance, the large-scale degradation of arable land in the Shivaliks in the North-west of India and shifting cultivation in the north eastern Himalayas. That is where agricultural diversification and livelihood security of farmers becomes the central point when we talk about sustainability of agro-ecosystems.

We at ANRCM are very appreciative of the fact that so many scientists and scholars have chosen to joins us to raise issues and provide solutions for better management of resources. Before the technical sessions, we have a plenary session

with top scientists and research managers sharing their views on resource conservation.

I derive immense pleasure to announce that in the plenary session we will be joined by Dr. Srinivasa Rao, Director, ICAR-NAARM, Hyderabad; Dr. B. Gangwar, Ex-Director, ICAR-IIFSR; Dr. G.G. Rao, Ex-Head, ICAR-CSSRI, RRS Bharuch; Dr. S.S. Singh, Director Extension, RLBCAU, Jhansi, U.P. and Dr. S.K. Sharma, Zonal Director Research, MPUAT, Udaipur, Rajasthan.

I am sure that we will be having fruitful discussions throughout these two-days of the web-conference and look forward to having some concrete recommendations.

Prof. Vikas Sharma
Organizing Secretary

National Web-Conference

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System based resource management for ensuring livelihood security and environment sustainability

B. Gangwar
Former Director, ICAR-IIFSR, Modipuram
Professor and Head, Institute of Agricultural Sciences,
Bundelkhand University, Jhansi (U.P.)-284128

India has made phenomenal progress in food grain production since independence registering nearly 6 times gains in food grain production from 51 mt in 1950-51 to 295 mt in 2019-20. But cconcerns about stagnating productivity, increasing production costs, decreasing profit margins, declining resource quality, depleting water tables and increasing environmental problems are considered the major factors to look for alternative technologies.

Presently, focus is being given to reduce the cost of production and increase use efficiency of inputs in which cropping system investigation proved as a useful tool for studying the response in sequence (s). Based on area and spread of crops, 30 important cropping systems have been identified in different agro-ecological regions of the country. However, the cropping systems considered to be the major contributors to national food basket are; rice-wheat (11 m ha), rice-rice (6 m ha) and coarse grain based systems (11 m ha). Amongst systems, the share of rice and wheat together is rated as the highest about 76% to the food grain production, while rice-wheat system when grown in a sequence contributes 40%. Interestingly, most of the high-productivity systems in the country are cereal-based, having high resource demand and are grown in a monoculture fashion over the decades (e.g.; rice-wheat in Indo-Gangetic plains, rice-rice in coastal and high rainfall areas, and coarse-cereals based in low rainfall areas). This has resulted in emergence of second-generation problems like, over-mining of major and micro-nutrients, decline in water table, decline in factor productivity, reduction in profitability, and appearance of the new bio-types, pests and diseases, causing concerns to sustainability. The increased cost of inputs and resources for obtaining higher production through intensive farming calls for precision management. Under the present scenario, the major concerns are to jot down strategies proving crucial and cost effective. These concerns have given impetus to the pursuit of alternative crops and cropping systems in farming system perspective with new techniques of cultivation, which are environment friendly and more efficient in using natural resources. The system based site-specific crop management practices, which ensure high productivity, profitability and resource use efficiency, are considered very important. Therefore, an effort has been made here to discuss all the possible options of system based efficient recourse management for ensuring the livelihood security and environment sustainability.

Diversification of cropping systems

Crop diversification in areas, where continuous cropping of cereal-cereal systems is in vogue, has been advocated as one of the effective tools for minimizing the second-generation problems and to make a breakthrough in productivity and profitability. The crop diversification can deliver many agronomic and ecological benefits simultaneously, while maintaining or enhancing the scale of efficiency of production, In this regards, besides adoption of proper input management technologies, diversification of the systems through introduction of crops of diverse nature may be a good preposition to break the monotony of the predominant cereal

based systems and to sustain productivity over a period of time. For diversification of rice-wheat system, several options are available for different zones (Table 1).

In Punjab, crops like maize, moong bean, summer groundnut, fodder sorghum / maize in *kharif* offer viable and remunerative alternatives to the nutrient and water exhaustive rice crop. While crops like potato, Indian mustard, vegetable pea, grain- pea and sunflower are the substitute crop of wheat. In rice-wheat system, it is also possible to grow an early crop of potato that is harvested in first week of January for table purpose followed by late planted wheat with a total grain yield of 5-6 t ha^{-1} and that of tuber yield of 17-25 t ha^{-}. Onion is also proved a viable option in place of wheat. Further it was also noted that when sunflower is grown in spring season in place of late wheat, an additional yield of 2 t ha^{-1} of oilseed is obtained. Vegetables like okra and fodder crops like cowpea and sorghum can substitute rice in *kharif* season. The rice-potato-sunflower system gave highest wheat equivalent yield (22.6 t ha^{-1}), net income (Rs. 35,260 ha^{-1}), land use efficiency (86-87%), production efficiency (71 kg ha^{-1} day^{-1}) and cost: benefit ratio (2.26). Rice-potato-groundnut was also reported to be distinctly better than existing rice-wheat system in Punjab with wheat equivalent yield of 10.0 t ha^{-1} $year^{-1}$. Similarly, the yield of wheat under potato intercropping (4.2 t ha^{-1}) was higher than in rice-potato-wheat sequence (1.69 t ha^{-1}), while the yield of potato remained unaffected. In western plains of Uttar Pradesh, monetary returns and economic efficiency of land use improved considerably due to inclusion of legume/ oilseed crops in maize-wheat system. In central plain zone of Uttar Pradesh, inclusion of pulse and oilseed crops in rice-based crop sequences gives higher monetary gain over the rice-wheat system. Moreover, intercropping of pulses and oilseeds with recommended planting pattern after rice enhanced the net returns and improved soil health. The highest net return of Rs. 26,198 ha^{-1} $year^{-1}$, was recorded in rice-chickpea + linseed, closely followed by rice-linseed + Indian mustard and rice-mustard-green gram cropping systems. Considering the production, net return and land-use efficiency and maize-Indian mustard cropping systems proved most promising and remunerative in these areas. In eastern plains of Uttar Pradesh, rice-potato-cowpea and rice-potato-okra systems were identified to be potential alternatives to existing rice-wheat system for higher productivity and profitability.

For new alluvial zone of West Bengal, cropping sequence of rice-potato-jute has been reported to be most productive, with a rice grain equivalent yield of 16.94 t ha^{-1} $year^{-1}$ and profitability of Rs 51,465 ha^{-1} $year^{-1}$. Rice-wheat-groundnut was equally good with highest energy production (31.45 x 10^6 k cal ha^{-1} $year^{-1}$) and system stability index of 0.91. Maximum wheat-equivalent yield could be recorded by inclusion of potato or vegetable pea in between rice and wheat crops. Similarly, rice-potato-groundnut system was identified to be most productive, profitable and efficient at Kalyani. Under declining irrigation water availability conditions of Indo-Gangetic plain region, pigeon pea-wheat system was identified to be a potential alternate choice to rice-wheat system. In Bhilwara region of Rajasthan, maize grain equivalent yield increased by 1.44 t ha^{-1} in maize+cowpea (fodder) inter-cropping system and yield of succeeding wheat also increased by 0.84 t ha^{-1} over maize-wheat system. The highest net returns (Rs.2,292 ha^{-1}), benefit: cost ratio (3.1) and wheat equivalent yield (6.79 t ha^{-1}) were obtained from maize+ cowpea (fodder)-wheat cropping system . Instead of existing rice-rice system in coastal areas, rice-potato-sesame and rice-potato-cowpea for coastal areas of Orissa, rice-rice-soybean for coastal districts of Tamil Nadu, rice-fodder sorghum-groundnut for coastal areas of Gujarat and rice-groundnut for coastal districts of Maharastra, have been

identified to be more suitable with high productivity, profitability and stability. For Chattisgarh region, rice-berseem and rice-tomato have been identified to be most profitable, stable and efficient systems under assured irrigation. In this region rice crop is usually grown after winter grain legumes such as chickpea, lentil or field pea in double cropping systems. However, studies have shown the possibilities of raising a third crop of summer legume such as green gram, black gram, or cowpea. The increase in rice yields of 4.78 t ha^{-1} after cowpea, 4.50 t ha^{-1} after green gram and 4.28 t ha^{-1} after black gram could be obtained compared to 3.41 t ha^{-1} after maize fodder

System based Integrated Nutrient Management

The nutrients are being applied on general recommendations made by different state Agricultural Universities long back. The rate of productivity increase is declining in recent years largely because of the facts that the nutrient removal acceding nutrient replacement. In fact, with the continuous cultivation of exhaustive crops, the deficiency of secondary nutrients like sulphur and micronutrients *viz.*, Zn, Mn, Fe has become very common. So much so, the deficiency of potassium is also noticed and affecting the yield of rice, wheat, sugarcane, rapeseed and mustard etc. Therefore, there is an urgent need to create awareness among the farmers to make use of fertilizers based on soil test analysis but the non-availability of micro-nutrient analysis laboratories do not encourage the application of micro-nutrient. Moreover, the availability of fertilizers like potassium, which completely is being imported, all the other factor makes the problem of balanced in application of nutrients more specific. The imbalance application further aggravated on account of the decontrolled phosphoric fertilizers. As a result, the soil fertility has deteriorated and becoming a yield limiting factor. The effective nutrient management is considered key factor to sustain the productivity of cropping systems. It has been realized to cope up the declining trend in factor productivity, by following system-based integrated nutrient management. of rice-wheat system in *Typic Ustochrept* soils of western Uttar Pradesh. The long-term studies conducted in coastal areas have revealed that integrated nutrient management is desirable for long-term sustainable productivity. The increase in nutrient doses up to 25% of recommended dose of fertilizers was found desirable. Similarly, the application of sulphur @ 25 kg/ha at Maruteru and 10 Kg Zinc through Zn SO_4 ha^{-1} along with recommended dose of NPK/ha at Bhubneshwar was better for obtaining higher in rice-rice system. The on-farm studies on region specific constraints of nutrient management have pronounced the increase up to 56% over farmers practice. Inclusion of legume crops (grain, fodder, and/or green manure) within cereal-based cropping systems, regularly or intermittently, is of great help due to their soil ameliorating benefits. Recycling of crop residues may be a potential organic source to sustain the soil health. Incorporation of crop residues of either rice or wheat increased the yield and yield components of rice and nutrient uptake and also improved the physico-chemical properties of the soil which provided better soil environment for crop growth. In eastern Haryana, the average productivity of rice-wheat system was the highest (11.46 t ha^{-1} $year^{-1}$) when residues of both the crops were recycled back *in situ*. The advantage was 0.60 and 0.62 t ha^{-1} $year^{-1}$ over their burning and removal, respectively. Studies carried out with cereal-based cropping systems under All India Coordinated Research Project on Cropping Systems have established that 25-50% fertilizer-NPK dose of *kharif* crops can be curtailed with the use of farm-yard manure (FYM), *Sesbania* green manure or green leaf manure or crop residues in rice-rice system under different situations. In long-term experiments on integrated

nutrient management in rice-wheat system, application of 50 per cent of recommended NPK + 50 per cent N through crop residues in rice followed by 100 per cent NPK in wheat through fertilizer could stabilize yields of rice-wheat system at Kanpur, whereas 50 per cent N need of rice can be substituted by FYM, followed by 100 per cent NPK in wheat at Ludhiana. At Jabalpur, the 50 per cent of recommended NPK + green manuring could stabilize yields of both the crops, whereas at Masodha, yields of rice and wheat were stabilized under application of 50 per cent of recommended NPK + crop residues. At Kalyani, 75 per cent recommended NPK + green manuring in rice followed by 75 per cent of recommended NPK in wheat could stabilize yields of rice-wheat system and saved 25 per cent N fertilizer in winter season. Higher system productivity, organic carbon as well as improved soil fertility was observed when recommended dose of NPK + 5 t FYM ha^{-1} were applied in rice-wheat system.

The site-specific nutrient management (SSNM) involving nutrient application on soil test level, yield goals and other factors which influence crop response to nutrient application is desirable including micronutrient application is recommended for obtaining targeted higher productivity. The site-specific nutrient management studies conducted in rice-wheat system at 10 locations and at 6 locations in rice-rice cropping system revealed that for the rice-wheat system as a whole, the best gain yield under SSNM was 13289 kg/ha in comparison to 9034 kg/ha under farmers practice (FP) giving a yield increase of 3356 kg/ha. The extra grain yield obtained by growing rice + wheat through SSNM (over FP) ranged from 414 kg/ha at Ludhiana to 5345 kg/ha at Modipuram.

Crop Establishment and Conservation Tillage

In India, efforts to adopt and promote resource conservation technologies (RCTs) are in increasing demand among stakeholders in intensively copped areas as in IGP but there is limited use in other parts of India due to inappropriate knowledge about location specific technologies. Traditionally, the crop establishment includes repeated ploughing, planking and pulverizing the topsoil. Repeated tillage operations delay planting, escalate costs, reduce profits and needs more water for crop production. Therefore, crop establishment and tillage practices are considered very crucial for resource saving. The results of experiment at Modipuram, have revealed that crop establishment and reduced tillage practices in rice-based cropping system gave higher productivity of rice-wheat, rice-chickpea and rice-mustard crop sequences over other methods of crop establishment. The important resource saving techniques are zero tillage, furrow irrigated raised bed system and precision land leveling. However, conservation agriculture is yet to be focused in other parts of the country based on local needs and available resources.

Location Specific Water Management

Water is a crucial input for raising crops and a finite source must be utilized with care. It should be applied in such way that neither it is in excess nor in short supply. Only one per cent of water earth is considered ideal for use. It governs the growth and development of living life by diminishing the starvation. Therefore, it is pertinent to focus our programme in direction that each drop of water should be used cautiously by making right method of irrigation, right time and depth of irrigation and quality of irrigation should also be ascertained carefully. In rainfed areas, water harvesting and recycling is the only option to provide either life saving or supplementary irrigation ensuring the stability in the productivity. Likewise, where under ground water is of poor quality, grow only crops require less water like cotton, pigeon pea and cluster bean during *kharif* season and gram, wheat

rapeseed and mustard preferably in winter season. High water requiring crops such as sugarcane, rice, berseem, turmeric, mentha, should categorically be discouraged. In addition, emphasis should be given on conjunctive use of water, crop establishment technique for high yield realization. The timing of first irrigation in wheat is very crucial on realizing high yield level. The missing of irrigation at crown root initiation caused yield reduction up to 26% because the moisture content in the zone where fertilizer was applied by drilling at sowing has become depleted and hence availability of the nutrients is reduced. The application of irrigation also helps to ensure the balanced supply of nutrients. The subsequent Irrigation schedules of 06, 0.9 and 1.2 IW/CPE had significant effect on wheat yield and the significantly higher yield was recorded at the water irrigation schedule of IW/CPE of 1.2 and the interaction effect was not significant (Table 6). Among field crops rice is the major user of water. Irrigation scheduling in rice is therefore crucial to save the irrigation water. Moreover, scheduling of irrigation in other crops, on most critical stages depending upon the availability of water is also important for ensuring good yield of crops in cropping systems. The studies conducted under All India Coordinated Project on Water Management have clearly shown that irrigation at 3 day after disappearance of ponded water in rice was better at most of the locations. Similarly, scheduling of irrigation in wheat at critical stages is desirable. Similarly, in a study at Kanpur, irrigation in rice at hairline cracking stage in soil proved better for saving irrigation water (20.5%) and realizing almost same productivity of 4.57 under disappearance of water and 4.73 t/ha under hairline cracking stage in soil.

Integrated Insect-Pests and Disease Management

The diverse systems can have a major influence in limiting diseases, pests and weeds. The disease incidence in cowpea intercropped with maize was significantly lower than in mono-cropped cowpea. It was further reported that wider intra-row spacing reduced disease incidence and severity significantly in both mono-crop and intercrop patterns compared with closer spacing. The effect of interaction between cropping pattern and intra-row spacing was highly significant on incidence and severity. Sorghum ear- head fly damage was extremely rare where pigeon pea was planted in alternate rows. In another study he observed that incidence of root-rot of cotton caused by *Rhizoctonia solani* fungus appreciably reduced by inter-cropping of dew gram. The dew gram intercropping caused moderating effect on soil temperature increase, which is un-favorable for the parasitic activity of the fungus. Intercropping of coriander in autumn- planted sugarcane prevents top borer attack in sugarcane. Garlic and fennel intercropping also reduces incidence of top borer in sugarcane. There was no need to apply insecticides for the control of top borer in sugarcane intercropped with these spices crops. The wilt incidence in sugarcane when grown sole and also with companion crops like coriander, raya, wheat and potato showed that with companion crops of raya and coriander, the incidence of wilt was the lowest (8-11%) in comparison to sole crop where it was 23 per cent. Wheat and potato also reduced incidence of wilt in sugarcane. Similarly, other companion crops such as wheat, barley, garlic, onion, coriander, linseed and mustard reduced the incidence of red-rot in sugarcane. Among different companion crops, Linseed and mustard showed 2.2 to 6 per cent incidence of red-rot in sugarcane (on clump basis) while in sole sugarcane 23.8 per cent incidence was recorded. Besides reducing disease incidence, intercropping also improved cane yield.

Site Specific Weed Management

Inclusions of certain crops in sequential and inter-cropping systems have shown their exceptional smothering effect on the obnoxious weeds to a considerable degree, thereby reducing the herbicides load to a greater extent. For example, Johnson grass (*Sorghum halepanse*) become predominant weed in continuous maize-based systems but can be controlled by rotating with cotton. Similarly, *Phalaris minor* weed intensity was reduced to a great extent when wheat was replaced with potato, rapeseed and mustard and *rabi legume*s. Likewise, replacing of rice with any other *kharif* crops resulted in *Phalaris minor* elimination. Adoption of sugarcane-wheat system in place of rice-wheat brings down *Phalaris minor* infestation to almost negligible level, which was otherwise, not achieved even through herbicides. Integrated weed management involving use of herbicides in rotation, zero tillage and crop diversification for effective management of *Phalaris minor* in rice-wheat system have also been suggested. In maize-potato cropping system, inclusion of pearl millet (for green fodder) during summer was also found advantageous in reducing *Cyprus rotundus* in succeeding crop of maize and potato. Raising of green manure (*Sesbania aculeatae*) during dry season led to reduced weed problem in succeeding rice crop under rice-rice system in Tamil Nadu. The incorporation of press mud @ 10 t ha^{-1} along with Azolla inoculation @ 1.0 t ha^{-1} was comparable with two hand weedings for weed control and crop yield. Growing of legumes in summer helps in reducing the weed biomass at early stages of rice and wheat. In addition, intensification and interruptive cropping in rice-wheat system, the *phalaris* minor may be minimized up to 55-91%.

Bio-intensive complementary cropping systems for resource conservation with high productivity

The concept of "Bio-intensive complementary cropping systems" was defined as growing of morphologically and physiologically different two or more crops in association under different land configurations which complements each other and subsequent crops on one hand and saves the resources on the other (Gangwar *et al.,* 2018).

Bio-intensive System of raising maize for cobs + vegetable cowpea (1:1 ratio) on tractor made broad beds (BB) and *sesbania* in furrows during *kharif* and mustard in furrows and zero till sown 3 rows of lentil on broad beds in *rabi* while zero till sown 3 rows of green gram on beds in summer (for grain and residue incorporation) was found to be suitable for marginal and small farm holders. The system produces the yield of 18.32 t ha^{-1} as rice equivalent with productivity of 50.2 kg grain $ha^{-1}day^{-1}$ and profitability of Rs.363 $ha^{-1}day^{-1}$. The complimentary effects could be reflected in the system as in broad bed and furrow (BBF) system, the furrows served as drainage channels during heavy rains in *kharif* which were utilized for in-*situ* green manuring with 35 t ha^{-1} green foliage incorporated after 35 days of sowing and timely sown mustard crop in these furrows resulted a good harvest 1.94 t ha^{-1} and a bonus yield of lentil (1.44 t ha^{-1}) can be harvested. In the summer season green gram could yield 1.05 t ha^{-1} grains while incorporation of green foliage of about 4 t ha^{-1} in the soil further helps the system favorably. The cost of cultivation of bio-intensive complementary cropping system ranged from Rs 48000 to 64500 per ha. The output in terms of rice equivalent yield jumped from 6.7 to 18.3 t ha^{-1}. In overall 40% water, 10-20% energy, 30-40% nutrients and 50% pesticide use could be saved on one hand while productivity could be doubled on the other when compared to existing rice-wheat system.

Round the year income through farming system

Rice-poultry-fish-mushroom integration studies conducted during 1987-1992 at Coimbatore revealed that a net profit of Rs 11,755/year can be obtained in 0.4 ha area while in conventional cropping system with rice-rice-green manure/pulses gave a net income of Rs 6334/year only from the same area (Rangaswamy *et al.*, 1996). The land based enterprises such as dairy, poultry, fishery, mushroom, biogas etc were included by Behera and Mahapatra (1999) to complement the cropping programme to get more income and employment for small farmers of Odisha. A net return of Rs 58367 can be realized with an investment of Rs 49286 in 1.25 ha area which also generated 573 man days of employment with a resource use efficiency of Rs 2.18/Re invested thus ensuring the livelihood of small farmers. Rice based farming system comprising of crop components (Rice-pea-okra and sorghum-berseem-maize), dairy, poultry and fishery was the most suitable and efficient system and recorded higher system productivity and profitability under irrigated ecosystem of eastern Uttar Pradesh (Singh et al., 2006). The Indian Counsel of Agriculture Research through its All India Coordinated Research Projects on Integrated Farming System under Indian Institute of Farming System Research have identified 49 IFS models for 25 states for ensuring enhanced income, nutritional security and employment generation (ICAR, 2019) .

Conclusion

Through the system based site Specific precision crop management in intensive systems including tillage, water and nutrients, the future targets of food production are achievable. Diversified complimentary bio-intensive systems involving high value legumes, oilseed, vegetables and other crops deserved priority with emphasis on site-specific resource management especially tillage and nutrients in farming system perspective (including Organic Systems) as considered the powerful tool and best approach to ensure high productivity with nutritional security, profitability, livelihood security and environmental sustainability.

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Table 1. Efficient crop diversification options for rice-wheat farmers

Cropping system	REY	Productivity	Profitability	NUP	IWUP
K - R - S	**t/ha/yr)**	**(Kg/day/ha)**	**(Rs/ha/day)**	**(kg grain /kg nutrient use)**	**(Kg grain/ha cm)**
South Alluvial Plain zone of Bihar (Sabour)					
Rice-Wheat	7.7	21.1	38.6	21.4	116.7
Rice-Garlic-Maize	11.2	30.6	76.4	23.7	123.9
Mid high altitude Intermediate Zone of J & K (R.S. Pura)					
Rice-Wheat	9.2	25.3	87.4	26.4	53.2
Rice-Cauliflower- French bean	11.0	30.1	93.8	53.2	45.1
Central Plain Zone of Punjab (Ludhiana)					
Rice-wheat	11.0	30.0	33.0	25.1	53.4
Maize-Potato -Onion	18.2	50.0	84.2	45.1	140.2
Central Plain Zone of U.P. (Kanpur)					
Rice-Wheat	8.8	24.0	36.4	28.1	42.7
Maize-Potato-Sunflower	15.3	41.9	56.4	20.5	103.0
Vindhyan Plain zone of U.P. (Varanasi)					
Rice-Wheat	8.5	23.2	32.3	17.7	41.4
Rice-Potato-Green gram	14.3	39.2	58.2	22.2	50.8
Bhabar & Tarai Zone of Uttarnchal (Pantnagar)					
Rice-Wheat	11.9	32.7	91.5	23.9	101.1
Rice-Rapeseed-Sunflower	12.6	34.5	93.1	23.1	112.4
Plain Zone of Chattisgarh (Raipur)					
Rice-Wheat	8.6	23.7	90.2	32.0	146.3
Rice-Brinjal-Green manure	10.7	29.4	112.4	54.0	224.8
Key more Plateau and Satpura hill zone of M.P. (Rewa)					
Rice-Wheat	6.7	18.4	53.7	16.7	44.3
Rice-Berseem (f)-B. Seed	10.5	28.7	103.3	47.7	94.4
South Gujrat Heavy Rainfall Zone (Navsari)					
Rice-Wheat	6.9	18.9	48.3	20.9	40.6
Rice-Onion-Veg. cowpea	8.6	23.5	52.2	22.0	42.8
Vindhyan Plateau Zone of M.P. (Jabalpur)					
Rice-Wheat	5.4	14.6	33.4	14.1	35.3
Rice-Berseem (f)-Berseem Seed	7.2	19.6	62.4	23.8	94.1
Eastern Plain Zone of U.P. (Masodha)					
Rice-Wheat	7.1	19.4	37.0	15.9	37.4
Rice-Potato-Green gram	15.5	42.3	97.9	11.5	29.7

Source: Gangwar *et al.,* 2007. K, Kharif; R, rabi; S, summer; REY, rice equivalent yield; NUP, nutrient use productivity; IWUP, irrigation water use productivity

Coastal Saline Soils of Gujarat – Problems, Reclamative Measures and Management Strategies

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Abstract

Sustainability of an eco-system rests on the scientific management based on a sound database. In coastal regions, that are in close proximity to the sea, salinization may lead to changes in the chemical composition of natural water resources, degrading the quality of water supply to the domestic, agriculture and industrial sectors, loss of biodiversity, taxonomic replacement by halo-tolerant species, loss of fertile soil, collapse of agricultural and fishery industries, changes in local climatic conditions, and creating health problems; thus, affecting many aspects of human life and posing major hindrance to the economic development of the region. Managing the coastal agricultural eco-system is more complex when it is affected by natural causes like sea water ingress and introduction of large scale human interventions. Such situation is prevailing in the coastal districts of Gujarat state where salinity of the agricultural lands is constantly on the increasing trend. The problems of environmental degradation in Gujarat are as diverse and complex as the ecological fabric of the state. Gujarat State is sharing the longest coastal line in the country i.e. 1600 km out of which Kachchh and Saurashtra where salinity ingress has spread its tentacles far and wide on the 1125 km long coastal belt engulfing 779 villages with a population of 13.3 lakhs. To address the severe problem of water and land salinity in the coastal regions of Gujarat, the State Government appointed two High Level Committees (HLC-I and HLC-II) in 1970s and 1980s. Various measures involving engineering, agriculture, forestry, social and legal aspects have to form a part of an integrated approach to reduce the water and land salinity problem and improve conditions in the salinity affected areas. It has become mandatory to develop location-specific programmes on water allocation based on soil, climate, water and crop parameters, with minimal dependence of abstraction of ground water but with increasing dependence on other means like artificial recharge of the aquifer, recycling of water and conjunctive use strategies with overall target to increase the water productivity and cropping intensity while simultaneously conserving the ecosystem. In the present paper, aspects related to coastal salinity issues, measures undertaken as per the HLCs, works undertaken by other agencies mainly in water conservation and some agro-interventions evolved at CSSRI, Bharuch ie., cultivation of economic halophytes, forages, seed spices, salt tolerant crops like cotton and wheat, fruit crops, farming system models, conjunctive use strategies that are ideal for coastal saline soils of Gujarat are elaborated.

The Problem

Soil salinity is one of the major environmental problems affecting extensive areas of land in both developed and developing countries. It is the product of complex interaction of many variables, which lessen the current and/or potential capability of soil to produce goods and services. In general, the subsequent changes in land use patterns mainly due to agricultural intensification processes together with many unfavorable natural conditions have accelerated soil salinity problems in many parts of the world. While the problem has caused immense loss to agriculture, its further spread provides a grim picture.

It is reported that about 6.73 Mha of land is salt affected in India (NRSA and Associates, 1996) of which 2.22 Mha is present in Gujarat State. The problems of environmental degradation in Gujarat state are as diverse and complex as the ecological fabric of the state. While some of the problems are wide-spread and operate over long term, the others are mainly localised and more intensive in their impacts. Soil and water salinity problems are essentially multi-sectorial and are complex in nature. Vast areas are in imminent danger of turning barren and production and productivity have simply declined due to secondary salinisation. Soil salinity problems are further compounded where the ground water is highly saline and such areas *by and large* remain barren for want of economically feasible technological interventions and thereby affecting the livelihood of the farmers because of low productivity of the existing farming practices. The adverse effects of salinity have put the food and nutritional security at stake while creating environmental pollution and affecting health.

Coastal Saline Soils

Coasts are dynamic ecosystems, undergoing changes in form and processes in time and space in response to oceanographic conditions and geomorphic features. India has a long coast line of 8129 km spread over as many as 9 states, 2 union territories and 2 island ecosystems and two archipelagos is the sixth one in the world and has been subjected to many spells of sea level changes. The east and west coasts are markedly different in topographic setup, tectonic features and geomorphic framework. The west coast is relatively narrow as compared to east coast and lack any major delta formation. The coastal soils exhibit a great deal of diversity in terms of climate, physiographic and physical characteristics as well as in terms of rich stock of flora and fauna. Coastal ecosystem provides very delicately balanced resources, that sustain substantial human and animal population. The resources, if properly managed, can contribute significantly to the GDP of the country.

Coastal ecosystem poses a delicate equilibrium between land and water masses amongst its different components but with high degree of vulnerability inspite of bountiful natural resources. Planning for effective and sustainable development of this ecosystem requires adoption of integrated approach to soil and water management in the first place, and through it or otherwise, necessary measures to conserve the ecology. Natural calamities like, cyclones, storms, tsunami, seas ingress, tornado are the frequent visitors in this area causing monumental losses to the lives and properties of the people living in the coastal regions. The Coastal region is likely to face severe challenges in future due to rise in sea level resulting from global warming. Coastal areas in India and elsewhere are *by and large* heavily populated. About 50 to 70 per cent of the global population lives within 100 km of the coastline covering only about 4% of the earth's land, thereby drawing heavily on coastal and marine habitats for food, building sites, transportation, recreational areas and waste disposal. The major problems encountered in these areas are:

- These lands are subjected to the influence of tidal waves and periodical inundation by tidal water;
- Shallow water table enriched with salt contributes to increase in soil salinity during winter and summer months;
- Heavy rainfall resulting in excess water during Kharif season;
- Poor surface and subsurface drainage conditions;
- Lack of good quality irrigation water and acute salinity during Rabi;

- Poor socio-economic conditions of the farming community limiting introduction of high investment technologies.

Salinity build-up in soil and soil quality

Salinity build-up in soil due to salinity ingress of ground water takes place through the following processes: (1) excessive and heavy abstraction of ground water from the coastal plain aquifers; (2) sea water ingress; (3) tidal water ingress; (4) relatively less recharge, and (5) poor land and water management.

Seawater intrusion

Over-exploitation of ground water has rendered it vulnerable to sea intrusion in different pockets mainly in Saurashtra region, rendering danger to the sensitive aquifers on which a major chunk of the population depends primarily for water. Salt water intrusion takes several forms. Horizontal intrusion occurs as the saline water slowly pushes the fresh inland ground water landward and upward. The cause can be both natural (due to rising sea levels) and anthropogenic (abstraction of fresh water from the coastal wells). Pumping from coastal wells can also draw salt water downward from surface sources such as tidal creeks, canals etc.

Options for control of seawater ingress into aquifers include (1) modification of groundwater pumping and extraction patterns; (2) artificial ground water recharge; (3) injection barriers; (4) subsurface barriers and tidal regulators, check dams and reservoirs (Gururaja Rao *et al.*, 2012; 2013; 2014). However, for an effective solution to the problem of sea water intrusion in the coastal plain it is vital to develop location-specific optimization methods and models to identify and earmark ideal and suitable locations of the pumping wells and rates of withdrawal of the ground water. Studies carried out by CSSRI through artificial recharge of ground water (Gururaja Rao *et al.*, 2014) and the efforts by GSLDC (Gururaja Rao *et al.*, 2012; 2013) have paid dividends.

Irrigation water resources

In spite of coastal ecosystem presenting a delicate equilibrium among different components, there is however no firm strategy, as of now, for exploitation of water resources for irrigation and other purposes for long term solution in any sector. In order to have a appropriate coastal development by maintaining the water consumption to sustainable levels, the technological development should focus on artificial recharge of the aquifer, recycling of water, desalinization of sea water, improved irrigation water management practices and use of poor quality water. Thus, it is mandatory to develop location-specific programmes on water allocation based on soil, climate, water and crop parameters, with minimal dependence of abstraction of ground water but with increasing dependence on other means like artificial recharge of the aquifer, recycling of water, desalinization of sea and conjunctive use strategies with overall target to increase the water productivity and cropping intensity while simultaneously conserving the ecosystem. With a vision on source-wise water allocation for irrigation for enhancing the crop productivity and maintaining the stability of the coastal region, studies by Sen *et al.* (2012) indicated a step-wise increase in water use under different modes along with suggested increase in cropping intensity from 150% to 225% during 2020-2050. Field water balance model has been used to estimate surface water storage opportunities which should gradually dominate over ground water use for stability of the coastal plain.

Agriculture, horticulture, aquaculture, animal husbandry etc. are the primary livelihoods of the people living in the coastal areas but the productivity of all these sectors are much below the national average because of various constraints related to soil, water and climate. The socio-economic status of the population living in coastal areas is also much below the national status. It is essential that coordinated strategies for conservation and scientific utilization of the rich and diverse natural resources of the coastal region are adopted for improving the productivity and the livelihood of millions of resource poor farmers living in the coastal region and to protect coastal environment from the potentially catastrophic effects. It is the need of the hour to concentrate, share experiences and shoulder responsibilities to preserve the coastal ecosystem and to increase the overall productivity of the coastal region for improving the livelihood security of the millions of resource poor and disadvantaged farming communities living in the coastal region.

Scenario in Coastal Gujarat

In coastal Gujarat in general and Saurashtra region in particular, high ground water draft (Groundwater mining) compared to groundwater recharge resulted in lowered groundwater levels. Natural gradient of water is drastically changed in the vicinity of the sea and saline water has intruded in to the inland area. Pumping of water from deep strata has increased the demand of electricity and thus the cost of consumption. Impacts of the decline in water levels include:

- Drying up of open wells (shallow wells).
- Deep tube wells are required to be drilled at higher cost.
- Quality of ground water has deteriorated and problems of salinity are aggravated.
- Hardness, fluoride and nitrate have increased.

Along the coast, sea water is creeping underground into freshwater aquifers. Called salinity ingress, it is advancing at an unprecedented rate of half a km a year along the 1600-km-long coastline of Gujarat. Since the early 1970s, when the salinity ingress was first observed, there are over 2,500 villages that are currently affected. That salinity ingress covers 550 sq km new area along the coastline every year, the invasion is indeed insidious.

"Gujarat, with its all inclusive, sustainable and rapid growth, is emerging as a globally preferred place to live in and to prosper." Major problems encountered in coastal Gujarat state comprise

- Lands are subjected to the influence of tidal waves and periodical inundation by tidal water;
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- Poor surface and subsurface drainage conditions;
- Lack of good quality irrigation water and acute salinity during Rabi;
- Poor socio-economic conditions of the farming community limiting introduce-tion of high investment technologies

Thus, any salinity mitigation programme needs to have the following objectives

- To arrest salinity ingress from the sea water on to the main land
- To harvest important natural resource like rainwater in farm ponds

- To store rainwater on the other side of the reclamation bund in depressions/other water bodies like ponds etc.
- To recharge ground water and to improve the water table and also the water quality
- To provide life saving irrigation facilities for the farmers in the rabi season
- To arrest/check siltation and soil erosion
- To increase the food, fodder and fuel wood production
- To save productive agricultural land from becoming saline
- To increase area under irrigated farming through water harvesting structures
- To generate rural employment
- To improve socio-economic condition of the people including small and marginal farmers and landless labourers
- To increase community awareness on the possible beneficial effects of the interventions

Management Strategies: Actions taken by the Government of Gujarat

The coastal region of Saurashtra, stretching from Una to Madhavpur, comprises parts of Junagadh District (At present Junagadh and Gir Somnath Districts). It has rich agriculture lands and with continued abstraction of ground water using oil engines in sixties and electric pump sets in early seventies, the agricultural lands have been affected by sea water ingress into coastal aquifers at shallow depth resulting in salinisation of the soils and rendering the well water unsuitable for irrigation and human consumption..

Groundwater depletion

Increasing pressure of economic activities along the coast has caused considerable depletion of ground water resulting in underground surge of marine water. No wonder, two decades of development activities have caused an increase in the number of administrative blocks where withdrawal of ground water in the coastal region is not safe; from five in 1984 to 21 in 1997, with the total number of coastal blocks being 42 only. And, the number continues to vary.

Looking to the gravity of salinity and its devastating effects, Government of Gujarat had formed a High Level Committee 1 (HLC 1) in 1976 for Una-Madhavpur area and a High Level Committee 2 (HLC 2) in 1978 for Una-Bhavnagar and Madhavpur-Maliya area for study of issue of salinity ingress and for its management. These Committees, after traversing the problem areas, had suggested the following measures of various salinity ingress under four management systems (Table 1).

Table 1. Various measures suggested by HLC 1 and HLC 2 for mitigating salinity ingress in coastal Gujarat

Sr.No.	Various Works of Salinity Ingress Under Scientific System	
1	Management System	Regulation of lifting underground water and change in crop – System Change in crop System
2	Recharge System	Check-Dam Recharge-Dam Recharge-Well Recharge Reservoir Spreading Channel
3	Salinity Ingress System	Tidal Regulators, Weirs Fresh Water Barrier

4	Coastal Land Reclamation	Extraction Water Barrier Static Barrier Rejuvenation of salinity land of oceanic areas

The Government had taken up various salinity control and recharge measures recommended by the HLC-I, *viz.* construction of salinity control structures like Tidal Regulators and Bandharas located near the coast and Recharge structures like Check dams, Recharge Reservoirs, Recharge Wells, Recharge Tanks located inland on the rivers and local streams etc. In addition, construction of Nala plugs in the upper reaches of the area and afforestation works near the coast were also taken up initially by the Gujarat State Land Development Corporation and the State Forest Department with finances provided by the Salinity Ingress Prevention Circle.

The HLC 1 studied various issues pertainned to salinity ingress in Bhavnagar – Una Reach, Madhavpur – Malia Reach and Malia – Lakhpat Reach and suggested water quality monitoring during pre- and post- monsoon and to come out with water table and ground water quality maps. Saline soils in this region are presented in Fig. 1. Based on the High Level Committees' observations and the works suggested in the areas of Una-Bhavnagar and Madhavpur-Maliya region, construction of 13 Tidal Regulators, 29 Bandharas, 15 Recharge Reservoirs, 661 Check Dams, 28 Recharge Tanks, 4487 Nala Plugs and afforestation in 5867 ha of land have been completed. As far as Spreading Channels are concerned, out of 360 km of total length suggested, 141 km has been completed and about 105 km is under progress.

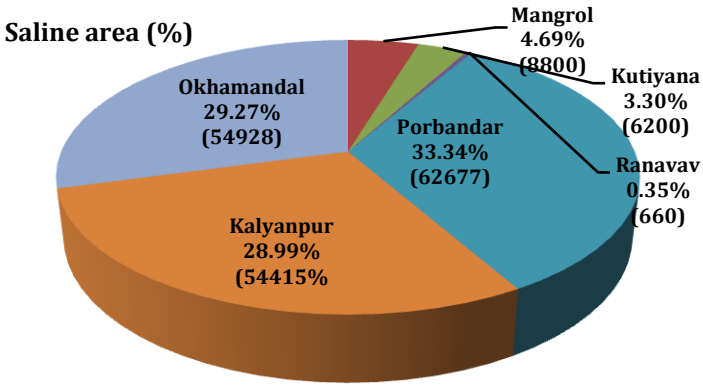

Fig. 1 . Salt affecated area in (Madhavpur - Okha Reach) - Values in paranthesis are actual area (ha)

The study further indicated a total of 226.49 mcm withdrawal had taken place against the recharge of 123.94 mcm, with a net over withdrawal/overdraft of 102.55 mcm in 1977. Harvesting rain water in water storage structures and rain water conservation further decreased the extent of salinity and enhanced crop production in the region. High rainfall further helped in improving the quantum of water storage with concomitant decrease in saline area. The report indicated Porbandar followed by Okha mandal and Kalyanpur had maximum saline area and Mangrol, Kutiyana and Ranavav had only marginal area under salinity. The salinity ingress mitigation measures had a profound influence on the benefited area, which has been brought under agriculture and allied activities. Thus the very planning of HLC I and HLC 2 have been proved beneficial in the coastal Gujarat.

The Committee recommended the following.

- Increasing Groundwater Recharge
- Maximum collection of rainwater in the lower reaches – By constructing recharge structures
- Ecological balance through Agroforestry Programmes
- Continuous monitoring of water table and ground water quality
- Maintenance of the water storage structures

- Optimum use of ground water and maintenance of ground water balance
- Electrifying the farm units opting for pressure irrigation methods

Salinity ingress in coastal areas – Control measures

Extent of salinity ingress in Una – Madhavpur during 1977 – 2015 indicate a graduate decline in distance of sea water ingress across all talukas suggesting the positive role played by the control measures. The expected decline has been found to be linear in these areas. Similarly, the extent of salt affected area in this region showed a declining trend which is primarily because of decline in salinity ingress (Fig. 2).

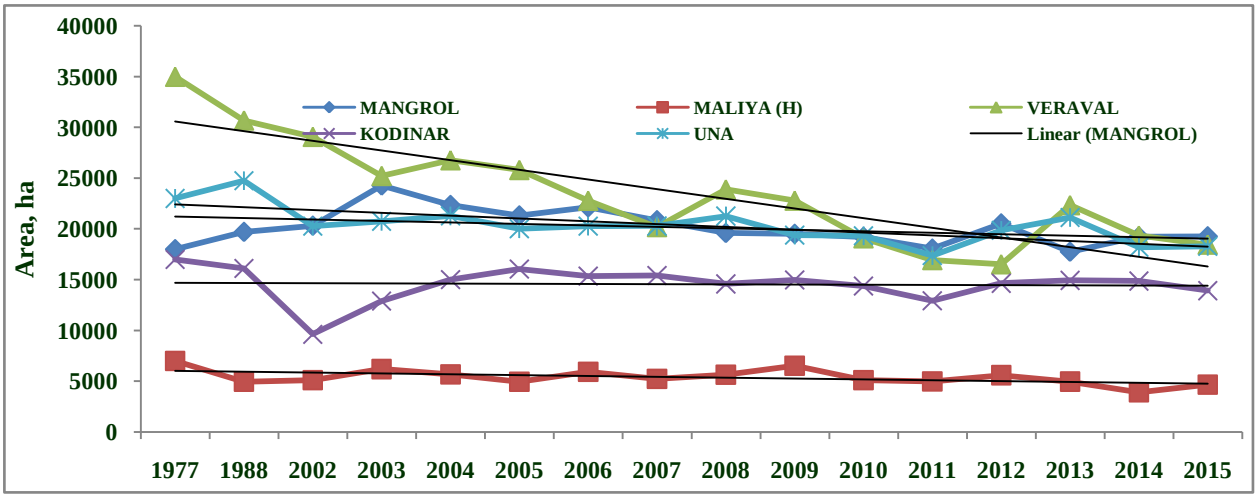

Fig.2. Extent of salt affected soils (ha) in different talukas in Una - Madhavpur Reach during 1977 to 2015

Benefits accrued by the salinity ingress projects

The works on controlling salinity ingress have been undertaken under the recharge and Salinity Ingress System which aim at conserving and recharging with fresh water/rainwater, improving the ground water quality and prevention of surface and groundwater salinity due to spreading of tidal water. The advancement of saline tidal water has been prevented due to the tidal regulators and weir. Moreover, the damages occurring to the fertile agricultural lands have also been considerably minimised simultaneously reducing the ground water salinity. The following benefits have been obtained primarily because of the completion of aforesaid works of Salinity Ingress.

The studies resulted in

- 74512 ha lands have been benefited due to the storage of 318.04 MCM of fresh water.
- Ground water recharging has resulted in improved ground water quality with concomitant rise in water table almost to a tune of 2.50 m in the region.
- Salinity mitigation measures also benefited about 2.6 lakh hectares of land getting saline.
- The ground water from its TDS of 2000 in 1988 has started declining due to the ground water recharging.
- Salinity ingress prevention structures, further resulted in higher crop yields which further increased the land value.
- Due to increase in the socio – economical condition (of people of this area), overall prosperity of this region has also been increased.

Salinity mitigation measures taken by other agencies

Further efforts by GSLDC in water conservation measures resulted in improvement in ground water quality, ground water table depth in the coastal districts of Gujarat. The works were evaluated by CSSRI RRS, Bharuch and the report

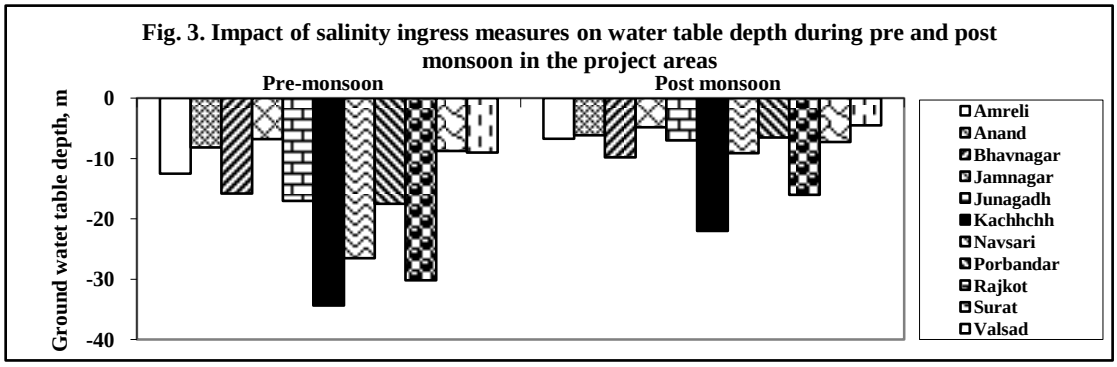

Fig. 3. Impact of salinity ingress measures on water table depth during pre and post monsoon in the project areas

highlighted that with the implementation of the scheme, the water table levels increased because of the recharge structures viz., percolation tanks, earthen water harvesting structures, check dams and other storage devices developed in different regions. Ground water table during pre and post monsoon phases (Fig. 3) resulted in improved impact of these devices as seen in Kutch, Rajkot and Jamnagar districts, where the water could be seen flowing in the check dams (Kutch district) or stores in the farm ponds (Rajkot district). The stored pond water also provides drinking water for livestock.

Ground water quality

The ground water quality in terms of salinity (EC) also showed significant improvement in that, the EC values have gone considerably down in the post-implementation phase (Fig. 4). The improved quality of water and prolonged availability of ground water thus has become a boon to the water-scarce areas. This enabled the farmers to provide additional irrigation and thus additional crops could be taken up. Ground water pH also showed significant decrease in all the location in the post-implementation phase.

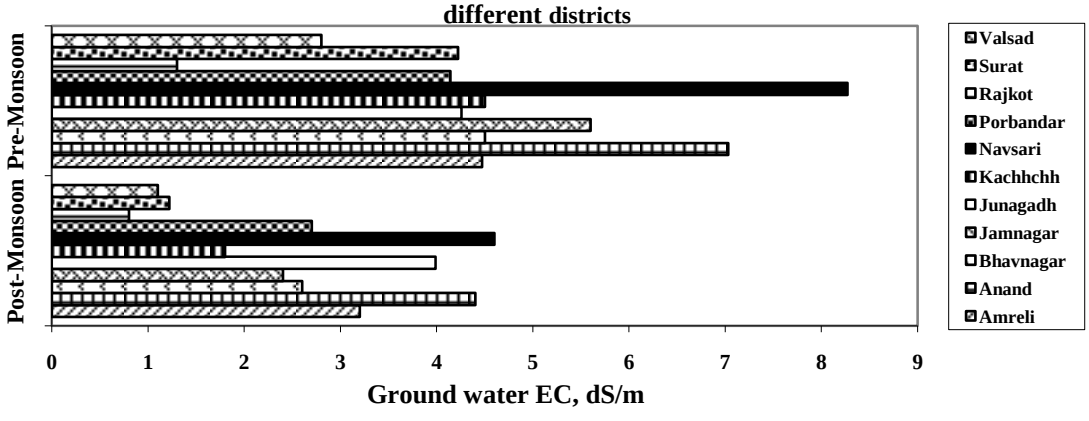

Fig. 4. Impact of salinity ingress measures on water quality (EC, dS/m) in different districts

Impact of salinity mitigation measures on agriculture

The salinity ingress has major impact on agriculture sector. Increase in level of salinity in water and soil has resulted in changing the cropping pattern drastically.

The area under horticulture has reduced gradually and no new plantations are carried out by the farmers, since irrigating mango orchards with saline water affects quality as well as quantity of the fruit. The cropped area of pulses has reduced in coastal areas. Groundnut, one of the major crops is replaced by cotton which is known for its salt tolerance capacity.

Agro -interventions using salt tolerant crops

In order to bring coastal saline soils under productive system, the Regional Research of Station, Bharuch (Gujarat) of Central Soil Salinity Research Institute has evolved some agro-technological interventions like halophyte cultivation for highly saline areas, cultivation of dill, Cultivation of desi cotton and salt tolerant wheat and cotton-pulse intercropping system for moderately saline soils, forages for meeting the dairy needs and conjunctive use of saline water for irrigating rabi crops like wheat, dill, safflower and mustard. The same have been disseminated to the farmers, Govt. Institutions and other Non-Government Organisations for further adaptation in different areas.

Desi Cotton and Wheat on coastal saline Vertisols

The studies indicated that in coastal saline areas, Desi cottons, in view of their higher salt tolerance and better response to saline water (because of saline ground water) were getting an edge over Bt lines and hybrids (Gururaja Rao *et al.,* 2013) which invariably need good quality water and also their salt tolerance is low. Desi cotton accessions G. Cot 23 gave yield in the range of 1.6 to 1.9 t ha^{-1} under the average salinity of 7.6 dS m^{-1}. In saline areas of southern, central and Saurashtra areas of Gujarat (EC range 5.9 to 7.2 dS m^{-1}), salt tolerant wheat varieties KRL 210 and KRL 19 gave yield in the range of 3.6 to 3.9 5 t ha^{-1}. The increase in number of farmers/user agencies going for the salt tolerant desi cottons and wheat varieties clearly indicated their impact on the agricultural scenario in the coastal Gujarat.

Saline lands having soil salinity of 8 to 10 dS m^{-1} had been profitably brought under cultivation with herbaceum cotton, 'G. Cot. 23' in all the three coastal regions of the state. This had resulted in gross income in the range of Rs 70,000/- to Rs 75,000/- ha^{-1} and net income of Rs 45,000/- to Rs 50000/- ha^{-1} , particularly in South Gujarat i.e., in Bojadra and Kalak with B:C ratio of 1.8 to 2.0. The lower salt tolerance coupled with less seed cotton yields of hybrids and Bt lines compared to herbaceum and arboreum (Gururaja Rao *et al.*, 2013; 2016) formed a basis for the farmers going for desi cottons in coastal saline areas. Further, earlier studies by Gururaja Rao *et al.* (2013; 2016) also indicated lower input costs primarily due to reduced disease incidence in desi cotton coupled with reduced number of irrigations.

Salt tolerant wheat KRL210 and KRL19 gave almost consistent seed yields (3.6 to 3.95 t ha^{-1}) of under soil salinity of 5.9 to 7.2 dS m^{-1}. Similarly, field trials conducted at Una, Veraval and Jafrabad talukas (coastal areas of Junagadh district) indicated that seed yield of 'KRL210' ranged from 3.4 to 3.95 t ha^{-1} across all the sites. Una and Veraval showed seed yield of about 3.8 t^{-1} ha at salinity ranging from 6.4 to 6.9 dS m^{-1} where as at similar salinity, the seed yields reduced by 0.2 q ha^{-1} at Jafrabad due to high clay content of the soil, since even low salinity become detrimental for crop production under clayey type of soils. However, the seed yield of the salt tolerant wheat lines were much higher than local variety 'Lok 1' which yielded about 2.5 to 3.0 t ha^{-1} indicating the superiority of these lines to saline conditions and their better suitability for saline areas of coastal Gujarat (Gururaja Rao *et al.*, 2016). The cultivation of salt tolerant varieties

(Gururaja Rao, 2004; Gururaja Rao *et al.*, 2016), thus is an effective biological approach by the farming community to manage coastal saline lands in Gujarat. Cultivation of salt tolerant varieties of crops in salt affected areas is thus considered as the very prudent option with less environmental degradation.

Halophytes based interventions

For highly coastal saline Vertisols, non-edible oil yielding halophytes *Salvadaora persica*, halophytic forages grasses like *Eragrostis* and *Aeluropus lagopoides* have been advocated. *Salvadora persica* was found to grow well on saline black soils having salinity up to 65 dS m^{-1} and found to yield well. A spacing of 4 m x 4 m has been found ideal for planting on saline black soils (Gururaja Rao *et al.,* 2004). Regreening of highly saline black soils that cannot be put under arable farming; reduction in salinity by 4th year onwards that enable to take up intercropping with less tolerant crops/forages. **Planting of *Salvadora persica* would fetch about Rs. 7000=00 per hectare.** Apart from this, the species provide a dwelling place for birds and enhances the environmental greening.

Cultivation of seed spice, Dill. Non-conventional crop like dill can be grown using residual moisture resulting in 2.6q/ha seed yield with net returns of Rs. 8000=00. This crop forms an ideal option for the state in general and the region in particular, which *by and large* faces water scarcity problems (Gururaja Rao *et al.* 2000). Under saline water irrigation, crop would yield net returns of Rs. 16500/- ha^{-1} with Rs. 6000/- per hectare as cost of cultivation. The benefit: cost ratio works out to be 2.75. This crop thus would help farmers of the region to go for the second crop in the rabi season on lands, which hitherto remain fallow due to water and salinity constraints. Thus dill crop can be taken up using residual moisture and/or with saline ground water. The green can be used as leafy vegetable, an additional source of income.

Cotton-pulse intercropping proved to be beneficial on moderately saline black soils

Farmers of the Bara tract in Amod, Vagra and Jambusar talukas and other parts of the state who take cotton as rain fed mono-crop, do face crop losses due to salinity development at later stages of crop growth. Under such situations, intercropping with pulses provides some remuneration to the farmer in the event of failure of cotton crop. On-farm trials have indicated cotton - cluster bean proved to be beneficial on moderately saline black soils having salinity of 4-6 dS m^{-1}. Cotton intercropped with cluster bean produced cotton seed yield at par with that of sole cotton. Increase in nitrogen up to 80 kg N ha^{-1} significantly increased the seed cotton yield under saline conditions. Cluster bean while improving the fertility of the soil provides an insurance against the failure of cotton crop. The system would fetch about 16000/= per hectare from cotton and further the pulses due to their nitrogen fixing ability enrich the soils with nitrogen. Cotton as well as pulses can be taken as rain fed crops, providing saline water irrigation, if available further boosts the crop yields.

Conjunctive use of saline water with surface water for crop production on saline black soils

As the real potential of land and water resources in the Bara tract was not assessed, the proper utilization of the land and groundwater resources is of paramount importance in agricultural production. Non-use of saline groundwater is not only making the crop production stagnant but also contributing to the

increase in the ground water table and salinity. The highly saline ground water in Bhal area in Gujarat renders is not suitable for irrigation as such and hence it needs to be blended with limited surface water. In the absence of inadequate irrigation water supplies in the region, technologies evolved for conjunctive use of saline groundwater in mixing and cyclic modes for growing *rabi* season crops like dill, mustard, safflower and wheat proved to be remunerative due to its long-term potential impacts on the economic development, employment generation and environmental improvement (Gururaja Rao, 2004).

The strategies developed for conjunctive use of saline water and ground water for four important crops of the region would improve the dill yield by 4.46 q/ha, mustard by 2.37 q/ha, safflower by 5.18 q/ha and wheat by 12 q/ha over the yield under unirrigated condition. The surface water saved per hectare would create 2 acre additional command under irrigation. This technology as well can be extrapolated to other canal command areas where the salinity problems are prevailing. This would pave for reclamation of waterlogged soils by 52.1% in Ukai-Kakrapar Command and by 65 % in Mahi Irrigation Command.

Surface water up to 66% can be saved by application of saline ground water (4 dS m^{-1}) at branching & flowering stage and surface water at seed formation stage with-out further increase in soil salinity in dill. In Safflower, irrigating with saline ground water (4 dS m^{-1}) at flowering and grain filling stages and surface water at branching stage, 86% increase in yields over that obtained under un-irrigated conditions.

In mustard, conjunctive use of saline water while saving 66 per cent surface irrigation water increases the yield by 123 per cent over the yield obtained under unirrigated conditions. In wheat, application of saline water (4 dS m^{-1}) at vegetative and tillering stages and good quality water at crown root initiation stage resulted in an increase of 180 per cent seed yield over the yields under unirrigated conditions

Farming system studies on saline Vertisols

Studies by Gururaja Rao *et al.* (2009) through farming system studies on saline Vertisols indicated that high water requiring crops like banana had the lowest water productivity (both in terms of economic yield and monetary gains) and also the benefit: cost ratio when compared to low and moderate water requiring crops like species and vegetables. Among the fruit species, papaya was found beneficial both in terms of water productivity and benefit: cost ratio and found suitable for Bara tract. The vegetable crops like tomato, brinjal, bottle gourd and cabbage, are moderate in water consumption and however, better money earners due to their continued yielding and thus provide subsistence income to the farmers. The spices, however, because of very low water requirement and high water-productivity have been found ideal for water scare areas like Bara tract. The B:C ratio of papaya, dill and coriander were higher than banana. Vegetables, brinjal, tomato and bottle gourd had water productivity and also higher B: C ratio than banana. These crops, with low crop duration and low water needs, form ideal components that provide regular income to the farming community. The crops like papaya, dill and coriander along with vegetables because of their higher water productivity and B: C ratio are found to be suitable for the saline Vertisols of Bara tract.

Jatropha curcas

Experiments conducted indicate response of *Jatropha* to saline water up to 10.4 dS m^{-1}. Plants irrigated with saline water at three different intervals i. e. once in 10, 20 and 30 days indicated that there was no significant difference between 20 and

30 days irrigated plants in terms of growth and seed yield (Sharma et al. 2008, 2010; Singh et al. 2015). This suggests that marginal quality of saline ground water can be saved if the crop is irrigated during hot summer once in a month. Though only a marginal decline in seed yield occurred in plants irrigated by saline water at 20 or 30 days, by foregoing this seed yield loss, there can be a saving of marginal saline water by 50-66 per cent. Since Dill also grows and yield well under saline water irrigation can be taken up as an intercrop in the initial years since *Jatropha* starts giving economic yield. This approach would provide the farmer returns even during initial years of *Jatropha* cultivation.

Way Forward

Coastal saline soils of Gujarat with various inherent problems can be brought under production by opting for location based strategies like soil management, water management, water conservation, cultivation by diverse crop interventions. While constructing physical structures help in prevention of salinity ingress, water conservation and improved water quality enabling better water quality for irrigation needs. Crops like cotton, wheat, mustard, dill, safflower enable farmers to go for food and cash crops and highly saline soils can also be brought under production system using economically potential halophytes and forages.

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Precision Farming for Natural Resources Conservation and Management

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Introduction

Precision agriculture is defined as the art and science of utilizing advanced technologies for enhancing crop production and minimizing potential environmental pollution/ degradation. This technology recognizes the inherent spatial variability that is associated with fields under crop production. Once the in-field variability (both, spatial and temporal) is recognized, located, quantified and recorded, it can then be managed by applying farm inputs in specific amounts at specific locations. Precision farming is a modern eco-friendly technology which offer openings to optimize yields and profits and reduces stress on natural resources, thereby leading to total quality management under heterogeneous and complex farming systems. The success of the precision farming system relies on the integration of these technologies into a single system that can be operated at farm level a sustainable manner. The major difference between precision farming and conventional farming is in the level of management. Conventional farming is based on uniform treatments across a field following single piece land management strategy, whereas precision farming is based on micromanagement concept. The management of variability is the heart of precision farming. Precision farming, which is also referred to as hi-tech farming, is known as technology enabled, information based and decision focused method of farming.

Precision Farming Techniques

Hi-tech agriculture uses the inputs most efficiently and judiciously to maximize productivity and profitability with minimum impact on soil and environment. Precision in terms of both time and quantity of inputs and agronomic practices, envisages a prospect, which can help in decreasing the cost of production without having any adverse effect on soil and environmental health. Thus the intent of precision farming is to match agricultural inputs and practices to localized conditions within a field to do the right thing in the right place, at the right time and in the right way. Precision farming basically depends on measurement and understanding of variability. The accuracy in assessment of the variability, its management and evaluation in space-time continuum in crop production decides the success in precision farming.

Although water is a renewable resource, its availability in appropriate quality and quantity is under severe stress due to increasing demand from various sectors. Agriculture is the largest user of water, which consumes more than 80% of the country's exploitable water resources. The overall development of the agriculture sector and the intended growth rate in GDP is largely dependent on the judicious use of the available water resources. While the irrigation projects (major and medium) have contributed to the development of water resources, the conventional methods of water conveyance and irrigation, being highly inefficient, has led not only to wastage of water but also to several ecological problems like water logging, salinization and soil degradation making productive agricultural lands unproductive. It has been recognized that use of modern irrigation method like micro irrigation is the only alternative for efficient use of surface as well as ground water resources. Apart from the economic considerations, the adverse effect of

injudicious use of water and fertilizers on the environment can have far reached implications. There is a need to develop agro technologies, which will help in sustaining the precious resources and maximize the crop production, without any detrimental impact on the environment. Water availability for irrigation is going to be a major constraint for agriculture in the near future. Efficient management of available water resources is hence necessary for expanding the area under irrigation. In this context, micro irrigation has most significant role to achieve not only higher productivity and water use efficiency but also to have sustainability with economic use and productivity. Fertilizer management is the most important agro-technique, which controls development, yield and quality of a crop. Fertilizer use efficiency is only 50 per cent in conventional practice of soil application. Location specific fertilizer management practices are essential for increasing fertilizer use efficiency for optimizing the fertilizer input and maximizing the productivity.

Efficient use of available irrigation water is essential for increasing agricultural productivity for the ever increasing population. This necessitates scientific management of available water resources, particularly in agricultural sector. Sustainability of any system requires optimal utilization of resources such as water, fertilizer and soil. The changing agricultural scenario of Kerala encourages more investment and horticulture is moving from rural confines to commercial ventures, which has proved to be intellectually satisfying and economically rewarding and hence has started attracting educated youth as well. In addition to the efficient utilization of natural resources, horticultural crops are highly remunerative too. The major components of precision farming include micro irrigation, fertigation, plastic mulching, crop geometry and integrated pest and disease management.

Micro Irrigation

The development of irrigation is given top priority in Indian economy as agriculture contributes to about 50% of the Gross National Product. The surface irrigation methods, which is widely practiced in India leads to enormous loss of water due to seepage and evaporation. This is due to poor distribution of water in farm due to inadequate land preparation and lack of farmer's knowledge in the application of water, which leads to excess application and deep percolation losses. Generally, under surface irrigation methods, only less than one third of the water released reaches the plants. The unscientific use of water has resulted not only in wastage of water but also has caused soil erosion, salination and water logging, which ultimately degraded the quality of the two basic natural resources-soil and water. Efficient use of available irrigation water is essential for increasing agricultural productivity for the alarming Indian population. Sustainability of any system requires optimal utilization of resources such as water, fertilizer and soil.

To bring more area under irrigation, it has become necessary to introduce micro irrigation for economizing the use of water and to increase productivity per unit of water. Micro irrigation is a method of delivering slow, frequent applications of water to the soil near the plants through a low pressure distribution system and special flow control outlets. It can be considered as an efficient irrigation method, which is economically viable, technically feasible and socially acceptable. It is the slow and regular application of water directly to the root zone of the plants through a network of economically designed plastic pipes and low discharge emitter. It enables watering the plants at the rate of its consumptive use thereby minimizing the losses such as deep percolation, runoff and soil evaporation. These systems deliver water to individual plants or rows of plants. The outlets are generally placed at short intervals along small tubing, and unlike surface or sprinkler

irrigation, only the soil near the plant is watered. The outlets include emitters, orifices, bubblers and sprays or micro sprinklers. The characteristics of micro irrigation are as follows:

- Water is applied at a low rate
- Water is applied over a long period of time
- Water is applied at frequent intervals
- Water is applied near or into the plant root zone
- Water is applied through a low pressure delivery system (1 to 2 kg/ cm^2)

Advantages of Micro Irrigation

- Increased beneficial use of available water.
- Enhanced plant growth and yield.
- Retarded weed growth.
- Improved application of fertilizers.
- Decreased energy requirement.
- Reduced operational labour.
- Suitable for irrigating hilly terrain and problem soils.

The major types of micro-irrigation systems are as follows:

i) Drip Irrigation

Drip irrigation is an efficient method of providing irrigation water directly into the soil at the root zone of plants and it permits to limit the watering closely to the consumptive use of the plants. Drip irrigation minimizes such conventional losses as deep percolation, runoff and soil evaporation. In drip irrigation system emitters and laterals are laid on the ground surface along the rows of crops. The emitting devices are located in the root zone area of trees. The cost of drip irrigation systems is reasonable on wide-spaced crops such as trees. The closer the crop spacing, the higher the system cost per acre.

ii) Bubbler Irrigation

In bubbler irrigation, water is applied to the soil surface as a small stream or fountain. Bubbler systems do not require elaborate filtration systems. These are suitable in situations where large amount of water need to be applied in a short period of time and suitable for irrigating trees with wide root zones and high water requirements. Discharge rates are generally less than 225lph.

iii) Micro Sprinkler

These are small plastic sprinklers with rotating spinners. The spinners rotate with water pressure and sprinkle the water. These are available in different discharges and diameters of coverage and can operate at low pressure in the range of 1.0 to 2.0 kg/cm^2. Water is given only to the root zone area as in the case of drip irrigation and not to the entire ground surface as done in the case of sprinkler irrigation method.

iv) Spray Jet

The spray pattern of jets is fan type, giving fine droplets and uniform distribution. Jets are mainly used to maintain adequate micro environment in the canopy area. They can be used to irrigate orchards, nurseries, vineyards, green houses and delicate plants such as flowers, vanilla etc. Mature large trunk-trees or trees having wide spread root zone can also be irrigated using jets. The spray pattern is either full circle or half circle.

v) Fogger

Foggers are recommended for orchards and greenhouses requiring a fine mist spray for humidity control. They are suitable for crops which need to maintain micro climate in the canopy area. They are simple in construction and has no moving parts. The spray pattern is misty and the droplets are very fine.

Fertigation

Simultaneous application of soluble fertilizers (plant nutrients) and water through an irrigation system is called fertigation. It is an eefficient and precise method of application of inputs and provides good environmental stewardship. Fertigation saves water, energy and nutrients. With drip/pressurised irrigation, fertigation is not optional, but absolutely necessary. Fertigation is a method of fertilizer application in which fertilizer is incorporated within the irrigation water by the drip system. In this system fertilizer solution is distributed evenly in irrigation. The availability of nutrients is very high therefore the efficiency is more. In this method liquid fertilizer as well as water soluble fertilizers are used. By this method, fertilizer use efficiency is increased from 80 to 90 per cent. Its advantages includes:

- Uniform application of fertilizers
- Placement in root zone
- Quick and convenient method
- Saves fertilizer
- Frequent application is possible
- Possibility of application in different grades to suit the stage of crop
- Micronutrients application along with NPK
- Saves groundwater from pollution

Plastic mulching

Mulching refers to the practice of covering the plant basin with some materials to prevent the evaporation loss. In traditional farming, organic mulch, mainly the residue of previous crops are used, which may contain all sorts of disease causing organisms, is not permitted in precision farming. In precision farming, hybrid or high yielding varieties are mostly used, which have less resistance to pest and disease infestation when compared to local cultivars. Also in precision farming the crop root zone always remain under moist condition due to the adoption of micro irrigation. Under this condition, if organic mulch is applied, it may totally damage the crop. Hence in precision framing it is always recommended to go for plastic mulching, which can enhance the water use efficiency and fertilizer use efficiency. The plastic mulching in addition to prevention of evaporation loss, helps to maintain the soil structure and regulates the soil temperature, which is essential for effective microbial activity. Plastic mulching completely eliminates the weed growth and prevents the leaching of nutrients during heavy rainfall.

Crop Geometry

Crop geometry refers to the practice of maintaining optimal crop to crop and row to row spacing, in order to accommodate maximum number of seedlings in the available land area. It is also referred to as high density planting.

Integrated Pest and Disease Management

Integrated pest and disease management is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties.

Conclusion

Scientific method of cultivation and judicious use of all the inputs, especially of water, is called upon to become cost competitive. Keeping in view acute water scarcity in many basins, efforts were made to introduce most efficient micro irrigation system at farms around 1970. Through the good management of micro irrigation systems, the root zone water content can be maintained near field capacity throughout the season providing a level of water and air balance close to

optimum for plant growth. In addition, nutrient levels, which are applied with water through the system (fertigation), can be controlled precisely. Fertigation gives successful results in terms of yield, saving in fertilizer and improvement in quality of the produce. During the dry season in humid areas, micro irrigation can have a significant effect on quantity and quality of yield, pest control and harvest timing. Kerala is frequently facing severe droughts followed by acute water scarcity for the last two decades. The major consumer of water resources is irrigation with about 70% of the total resources being used by this sector. Precision farming is one of the most scientific and modern approaches to sustainable agriculture that has gained momentum towards the end of 20th century. Precision farming actually is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production. It is a system for better management of farm resources. Precision farming offers a variety of potential benefits in profitability, productivity, sustainability, crop quality, food safety, environmental protection, on farm quality of life and rural economic development. This scenario forces us to think about efficient irrigation system like micro irrigation combined with fertigation to have more crop per drop.

Precision farming envisages increased profit and sustainability, improved product quality, effective and efficient pest management, surface and ground water protection and energy, water and soil conservation. Hence precision farming can be considered as the future of energy, soil and conservation and food security.

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Landuses in relation to soil physical characteristics and sustainability under semiarid irrigated conditions

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***Abstract**: The Rice-wheat is the dominant land use system in the state of Punjab resulted in over exploitation of ground water resources. Thus, it is of paramount concern to evaluate other land uses that requires less water and sustainable. Thus, the present investigation was planned with 4 land uses viz., fallow, rice-wheat, grasses and pear w.r.t their effect on soil physical characteristics and sustainability in surface and subsurface depth in district Ludhiana, Punjab. The organic C content was higher by 10, 30.9 and 24.9 % under land use rice-wheat, grasses, and pear than that under fallow. The land use grasses showed higher soil moisture characteristics curve and lower bulk density than that under land use rice-wheat. The larger MWD sizes were observed under pear, grasses and fallow than that under rice-wheat by 0.21, 0.51, and 0.41 mm. The saturated hydraulic conductivity was higher in magnitude by 56.09, 55.45 and 28% respectively under land use pear, grasses and fallow over rice –wheat, respectively. Of the evaluated land uses, pear and grasses proved to be more sustainable by retaining more moisture, maintaining better soil physical characteristics and soil organic carbon under semi-arid irrigated conditions in the state on long term gradual response.*

Introduction

Irrigated semi-arid alluvial tract of the Indo-Gangetic plains in South Asia is dominated by land use rice-wheat due to high productivity and profitability (Arora *et al.*, 2011). However, this land use has resulted in over use of the ground water. Thereby, threatening the sustainability of land use rice-wheat. The study by central ground water board states that Punjab, the North-Western part of India might turn into desert in 25 years, if overexploitation of its water resources continues at a current rate (Anonymous, 2019). The report further indicated that out of the 138 blocks covered, 109 are overexploited, 2 critical, 5 semi-critical and only 22 are safe. The findings states if extraction continued at the present rate, ground water resources upto 300m will exhaust in 20 to 25 years, while those at a 100 m will deplete within 10 years. However, such condition persists by following land use rice-wheat for the last 40 to 50 years in the state of Punjab especially in the central districts. Thus, it is imperative to evaluate the other land uses which are alternatives to land use rice-wheat. However, land uses other than rice-wheat require less water, more productive and sustainable (Singh, 2018). In this regard, some studies (Singh *et al.*, 2011; Chandel *et al.*, 2018) have been undertaken in semiarid lands in the state of Punjab.

Land use considered the different arrangements, activity and inputs which people employ in a certain land to produce change or maintain it. Land use affect ecological processes such as surface runoff, infiltration, hydraulic properties and soil resilience to environment impacts by manipulating soil physical environment (Fu *et al.*, 2000;Singh, 2016).

However, studies (Singh and Khera, 2008; Niu *et al.*, 2015;Chandel *et al.*, 2018) have been undertaken in semiarid lands of the state which compared the performance of different land uses on soil physical characteristics. However, such type of information has been lacking especially under semiarid irrigated conditions in the state of Punjab, which can prove beneficial in utilising less water, putting

less demand on ground water resources and maintaining better soil physical quality and sustainability. Also, the soil physical characteristics are linked to the soils ability to store and transmit water and air (Sur *et al.*,1981; Reynolds *et al.*, 2002, 2008; Iovino *et al.*, 2016); therefore, they may be able to assess the effect of land uses on soil water conservation. Thus, many basic soil physical characteristics can demonstrate 2- stage responses to change: A short term rapid response (i.e. from 1 to 5 Yrs.) and a long term gradual response (approximately ≥ 10 Yrs.) (Ferrara *et al.*, 2017; Reynolds *et al.*, 2014). Keeping these points in view, the 4 land uses (Fallow, Rice-wheat, Grasses and Pear) were evaluated in terms of their effect on soil physical characteristics and sustainability atLudhiana, in the state of Punjab.

Materials and Methods

Site characteristics

The study was carried out at Fruit Research Farm, Punjab Agriculture University, Ludhiana, Punjab. The site is situated at 30^0 54' 24″N latitude and 75^0 47' 30″E longitudes with an altitude of 247 m above MSL, in the central plains of Punjab under Indo-Gangetic Agro-climatic zone of India. It is characterized by sub-tropical and semi-arid type of climate. The mean summer temperatures are 38°C and touches 45°C with dry summer spells during last four to five years. Winter experiences frequent frosty spells especially in December and January and minimum temperature drops up to 0.5°C.

The mean annual recorded rainfall from 2000-2015 at Ludhiana is 758 ± 226 mm with coefficient of variation of 29.8 per cent (data not presented). However, majority of rainfall (74.9 per cent) occurred during June to September months with mean rainfall of 598 ± 237 mm and coefficient of variation 39.6 per cent. Whereas, coefficient of variation of rainfall in October to March months is quite high i.e. 52.7 per cent with mean rainfall of 112 ± 59 mm. The mean annual evaporation during 2000-2015 was 1600 ± 79.7 mm with coefficient of variation of 5 per cent (data not presented). The mean evaporation was 656 mm and 434 mm during summer and winter months respectively. Thus, the evaporation during the summer months was higher by 51.1 per cent over the winter months.

Soil sampling and analysis

The 4 land uses (fallow, rice-wheat, grasses and pear) following the Complete Randomized Design were selected at the Fruit Research Farm, Punjab Agriculture University, Ludhiana. The land uses such as pear and grasses were 25 and 15 years old respectively. However, the land use rice-wheat was contiguous to the fruit research farm, which has been in cultivation for the last 20 years. However, it is located at a distance 500 m away from the Fruit Research Farm, Punjab Agriculture University, Ludhiana.

The soil samples were collected from 4sampling points under each land use *viz.* fallow, rice-wheat, grasses and pear, following the grid sampling technique. In total,128 composite samples (4 land uses×4 sampling sites×2 depths × 4 replications) were collected. The four replicated samples from each soil depth i.e. 0-15 (Surface), and 15-30cm (Subsurface) were collected using the tube auger. The land uses grasses were cleared of any native vegetation prior to the collection of soil samples. Under the land use pear, the samples were collected after clearing the land surface of the accumulated leaf litter. However, the samples were taken under land use rice-wheat after the harvest of the rice crop.

The collected soil samples under different landuses were brought carefully to the laboratory and analysed for soil organic carbon with wet digestion potassium

dichromate (Walkley and Black, 1934) procedure and aggregate stability i.e. mean weight diameter (MWD) by wet sieving method (Yoder, 1936). The saturated hydraulic conductivity was determined by constant head method (Reynolds *et al.*, 2002). However, bulk density was determined by core method (Blake and Hartge 1986). Infiltration rate under each land use system was determined by Double ring infiltrometers (Reynolds *et al.*, 2002) by maintaining 3 replications. However, the particle size analysis was carried out as per the International Pipette method of Day (1965). The soil moisture characteristics curve determinations were made at various suctions (0.33, 0.5, 1, 5, 10 and 15 bars) with the help of Richard pressure plate apparatus (Richard, 1949). The maximum water holding capacity (MWHC, per cent) was determined by using the method of Richard (1954). However, the soil moisture retention parameter was computed by considering it as one half of the maximum water holding capacity.

The effect of land uses on soil physical and chemical characteristics of the surface and subsurface depth is described in Table 2. The pH varied from 6.8 to 7.5 in the surface soil depth under a land use system. The EC under a land use in the surface soil depth followed the trend: Pear (0.19 dSm^{-1}) >Rice-wheat (0.15 dSm^{-1}) > Fallow (0.11 dSm^{-1}) > Grasses. The organic carbon content was higher by 8.9, 28.8, and 46.6 per cent under land use rice-wheat, grasses and pear than that over fallow in the surface soil depth. The MWHC was higher by 3.6, 19.5, and 26.8 per cent under land use fallow, grasses and pear over the land use rice-wheat in surface soil depth. The subsurface soil depth under rice-wheat land use showed higher bulk density by 7.9 per cent over the land use fallow. However, the land use pear and grasses demonstrated lower bulk density by 10.4 and 12.9 per cent over the land use fallow at subsurface soil depth.

Statistical Analysis

Correlation matrix

The Pearson's correlation matrix analysis was performed among the different soil properties by using the SAS software (SAS 1997).

Tukeys honest significance difference

Land use systems and soil depth were used as independent variables (factors) and soil parameters as dependent variables. The significance differences of soil organic carbon and soil physical characteristics with land use systems and soil depth was tested using analysis of variance (ANOVA) followed general linear model (GLM) procedure at ($P \leq 0.05$). The Tukeys honest significance difference (HSD)test was used for mean separation when the analysis of variance showed significant differences ($P < 0.05$).

Complete randomized design

The data was statistically analysed following the Analysis of variance (ANOVA) technique by employing the Complete Randomized Design as described by Gomez and Gomez (1984).

Results and Discussion

Soil organic carbon

The soil organic carbon content differed significantly in surface soil depth under land use i.e. rice-wheat, grasses and pear than that under land use system fallow .The organic carbon content increased by 10, 30.9 and 24.9 per cent under land use system rice-wheat, grasses and pear over land use fallow. However, organic carbon content was significantly lower under land use system rice-wheat than that under other land use systems in subsurface soil depth. It was higher under land use systems fallow, grasses and pear by 69.2, 124.1 and 84.6 per cent

than that under land use system rice-wheat in subsurface soil depth. However, no significant differences were observed under land use system pear over fallow in subsurface soil depth. The decline in SOC under land use system rice-wheat than that over other land-use systems might be attributed to intensive land use system rice-wheat which might have aggravated organic matter oxidation and formation of hard pan at subsurface soil depth. The higher amount of organic carbon accumulation under land use pear may be due to leaf litter fall in the surface soil depth and through better root density in deeper layers . On the other hand, intensive cultivation, tillage and several other management practices hastens the loss of SOC by facilitating microbial activities and process of oxidation through other the land uses.

Soil moisture characteristics curve

The relationship in betweenvolumetric water content , as a function of soil matric generally decreased with increase in suction under a land use system. The land use system grasses occupied the higher position for ω, as function of ψ over the other land use systems. However, the same relationship under land use system rice-wheat occupied the lower position than that with other land use systems. For example, the soil moisture characteristics curve (SMCC) under land use system grasses over the land use system rice-wheat indicated 168, 141.8, 280.7 and 102 per cent higher in magnitude at soil moisture suction of 1, 5, 10 and 15 bars respectively in the surface soil depth. However, the SMCC under land use system grasses exhibited 33.7, 129, 229 and 273.5 per cent higher in magnitude than that under land use system rice-wheat at soil moisture suction of 1, 5, 10 and 15 bars respectively in the subsurface soil depth.

Soil moisture retention parameter

In the surface soil depth, the soil moisture retention parameter (S) is maximum under the land use pear (20.8 per cent), followed by grasses (19.6 per cent), fallow (17 per cent) and minimum under land use rice-wheat (16.4 per cent). The soil moisture retention parameter did not differ in magnitude under the land use fallow and rice-wheat in surface depth due to similar SOC content. The moisture retention parameter was higher under land use grasses (18.9 per cent) over the other land uses due to higher organic matter content at the subsurface depth. However, the same is lower under land use rice-wheat (16.3 per cent) than that over the other land uses at the subsurface soil depth. The soil moisture retention parameter decreases with increase in depth under a land use due to decrease in soil organic matter content and poor aggregation. The present study also indicated a significant and positive relationship of soil organic carbon with soil moisture retention parameter (S=1/2MWHC, r= 0.96) and mean weight diameter (MWD, r= 0.84).

Soil bulk density

The bulk density differed significantly under land uses rice-wheat and grasses over the land use fallow in the surface soil depth .The bulk density was higher by 10.3 per cent under land use rice-wheat over the land use fallow in surface soil depth. However, the bulk density was lower by 6.4 and 6.4 per cent under land use grasses and pear over the fallow in the surface soil depth. The bulk density differed significantly under land use system rice-wheat, grasses and pear than that under fallow in subsurface soil depth. The bulk density decreased by 12.9 and 10.4 per cent under land use grasses and pear over fallow in the subsurface soil depth. However, a land use rice-wheat indicated 19.3, 17 and 7.4

per cent higher bulk density over grasses, pear and fallow in the subsurface soil depth. Thus, the results demonstrated that the land uses maintaining the well aggregated, loose and porous soils have high organic matter content and lower bulk density while poorly aggregated soils have low organic matter content and higher bulk density that make total pore space greater .

Mean weight diameter

The land use rice-wheat, grasses and pear over the fallow affected mean weight diameter (MWD) in the surface soil depth. The land uses rice-wheat, grasses and pear over the fallow(MWD of 0.14 mm size) showed 0.21, 0.51 and 0.41 mm larger MWD in the surface soil depth. Similarly, the land use grasses and pear indicated 0.45 and 0.30 mm larger MWD than that under land use fallow that is 0.13 mm in the subsurface soil depth. The higher MWD was significantly and highly correlated with clay (r=0.96*) followed by plant available water (r= 0.95 *) and SOC (r= 0.84*) under a land use in surface soil depth. The larger MWD under a land use grasses were attributed to higher organic matter content as well as the better binding effect of root hairs.

In the subsurface soil depth, larger MWD size was observed under land use grasses (0.45) followed by pear (0.41mm). Under land use rice-wheat over the land use grasses and pear, there was 142.8 per cent and 95.2 per cent decrease in MWD size in surface soil depth. Similarly, there was 275 and 150 per cent increase in MWD size through land use grasses and pear over rice-wheat in subsurface soil depth. However, there was decline in MWD size in subsurface soil depth over the surface soil depth under land use fallow, rice-wheat, grasses and pear.

Saturated hydraulic conductivity

The K_{sat} differed significantly under land use grasses, pear, and rice-wheat than that over land use fallow in surface soil depth. The K_{sat} as affected by land use pear, grasses and fallow were higher by 264.7, 261.7 and 120.5 per cent over rice-wheat in surface soil depth. Similarly, in the subsurface soil depth, K_{sat} under land use pear, grasses and fallow over rice-wheat was higher in magnitude by 144.4, 588.9 and 138.9 per cent. The K_{sat} increased by 64, 65.3, 165 and 195 per cent under land use pear and grasses over the land use fallow both in the surface and subsurface soil depth respectively. The K_{sat} decreased by 28 and 58.1 per cent both in surface and subsurface soil depth under land use rice-wheat than that under land use fallow. This was further indicated through better K_{sat} in the subsurface soil depth over the surface soil depth under a land use. However, in other words, it was reverse for K_{sat} that decreased under land use rice-wheat over the land use fallow both in surface and subsurface oil depths. However, reduction in K_{sat} under land use fallow was more than 2 times in magnitude in the subsurface soil depth over the surface soil depth.

Infiltration

The I as a function of T under a land use rice-wheat, grasses and pear over the land use fallow differed in R^2 by 95.1, 95.3 and 95.8 per cent. The intercept (1.16) and slope (0.40) employing the power function in between I and T was least in magnitude under land use rice-wheat over the other land uses. However, under land use system grasses, where I as a function of T showed intercept of 2.43 and slope of 0.45 through a fitted power function relationship over the land use fallow with slope of 0.44 and intercept 1.43.

Sustainable land use

Based on different soil characteristics viz., Soil organic carbon , MWD, soil moisture retention parameter (S), cumulative infiltration (I) under different land uses , the land use grass and pear appeared to be more sustainable in terms of maintaining better soil quality and sustainability in surface soil depth (0-15 cm).

Ecologically incompatible land use and management practices like adoption of rice-wheat land use for the last 40 -50 years have affected the soil physical characteristics and demonstrate least sustainable land use from the point of view of creating imbalance in maintaining recharge–discharge relationship, soil physical characteristics and ultimately soil quality and soil sustainability. The degradation of natural ecosystems and intensive cultivation through the land use rice-wheat seriously impaired soil characteristics and decreased soil organic carbon, mean weight diameter, infiltration rate and saturated hydraulic conductivity (Celik, 2005; Singh, 2018). A recent study (Pulido-Moncada *et al.*, 2019) reported that subsoil structure was affected by compaction across depths with decrease in air filled porosity (33-46 %), relative gas diffusivity (37 to 61 %), increase in bulk density (4 to 8 %) and penetration resistance (40 to 50 %) at -100 h P at 30 -cm depth. However, study by Singh and Hadda (2018) revealed improved soil- plant-water relations along with higher maize yields could be achieved by breaking hard pan root restricting layers that formed due to use of heavy machines and puddling of rice fields at subsurface depth under rice-wheat land use .

Thus, there is a need for framing sustainable land management strategies and policies that evaluate the bad effects of rice-wheat land use over the other land uses in the central districts of Punjab, India. To further prevent degradation of soils, a conservation reserve programme must be encouraged which retain and promote the better land uses such as pear or grasses over the rice-wheat to improve the water retention, soil structure, soil physical characteristics and ultimately promote better soil physical environment and sustainability .

Conclusion

The present investigation suggested the land use that manage better organic carbon, and maintain better crop cover with least disturbance improve the soil physical characteristics and soil physical environment. The proposed management strategy which is attainable with land use pear and grasses on long term response shall help improve the soil physical characteristics, soil structure, soil physical environment and more sustainable under semiarid irrigated conditions in the state of Punjab.

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On-farm composting of municipal solid waste for restoration of degraded sodic lands and sustaining crop yield

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ABSTRACT

A research to overcome hazardous problems due to municipal solid waste (MSW) was developed by means of on-farm MSW compost and industrial processed MSW compost and their use in combination with inorganic amendments to restore degraded sodic soils and sustaining crop productivity. Seven treatment combinations with two decomposing agents like earth worms (Eisenia foetida) and cellulose and lignin degrading microbes (Aspergillus spp., Trichoderma spp. and Bacillus spp.) Amongst the treatments tested for producing on-farm quality compost treatment T_7 using 50% degradable MSW + 50% agricultural waste enriched with earthworms and microbes (T_7) produced cost effective and nutrient rich quality compost. This compost was used in combination with inorganic amendments with eight treatment combinations in a highly sodic soil (pH 9.8± 0.10, EC147μSm^{-1}±12.0,ESP±2.50) to monitor the combined effect of organic and inorganic amendments on soil amelioration and crop productivity. The study revealed that combined application of gypsum or phosphogypsum @25% gypsum requirement (GR) + on-farm MSW compost @10Mg ha^{-1} showed a significant improvement in soil physico-chemical and microbial properties and enhanced 4% and 12% rice and wheat grain yields respectively over the recommended practices of gypsum/phosphogypsum @ 50% GR. Adoption of this approach saved about US$ 433 ha^{-1} on account of reclamation cost by reducing gypsum/phosphogypsum dose from 50% GR to 25% GR with the addition of MSW compost and sustained crop productivity in degraded sodic soils.

***Keywords**: On-farm composting; municipal solid waste compost; agricultural wastes; inorganic amendments; restoration of degraded sodic lands; crop productivity*

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. Rapid industrialization and urbanization is increasing the amount of MSW day by day. Municipal Bodies/ Urban Local Bodies (ULB) in various cities collect the MSW, transport it to the dump yards and dispose it off in open ground dumping 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). Municipal solid waste compost (MSWC), with high organic matter content and low concentration of inorganic and organic pollutants represents a source of nutrients that can improve soil fertility, may contribute to restoring the productivity of salt affected soils (Lakhdar *et al.*, 2008).

In India, about 6.73 million ha are salt affected soils (Mandal *et al.*, 2009). Out of these, 2.8 million ha are sodic and spread in 194 districts of the country.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. The industrial processed municipal solid waste compost available in the market is very costly and beyond the reach of resource poor small and marginal farmers. Therefore, the present study was conducted to standardize the methodology for on-farm composting of MSW to get quality compost for restoration of degraded sodic land and enhancing crop productivity.

Materials and Methods

Standardizing on-farm 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. 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.

Changes in physico-chemical and biological 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.

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 ^{0}C 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.

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^{0}C for 48 hours. After incubation, the viable colonies were counted using colony counter (Dubey *et al.*, 2006).

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

Treatments	Stages	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	$75 x10^4$	$48 x10^4$

Synergistic effect of on-farm compost on restoration of sodic soils

Field experiment 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 2014-2015 in a highly sodic soils having pH 9.8, EC 1.74 dSm^{-1}, ESP 78, OC 1.30 g kg^{-1}. Three times replicated field experiment including eight treatments *viz.* T_1: Gypsum (G) @ 50% GR, T_2: Phosphogypsum (PG) @ 50% GR, T_3: G @ 25% GR + on-farm MSW compost @10 t ha^{-1}, T_4: PG @ 25% GR+ on-farm MSW compost @ 10 t ha^{-1}, T_5: G @ 12.5 % GR + on-farm MSW compost @ 10 t ha^{-1}+ pressmud @ 10 t ha^{-1}, T_6: PG @ 12.5% GR+ on-farm MSW compost @ 10 t ha^{-1}+ pressmud @ 10 t ha^{-1}, T_7: G @ 25% GR+ industrial processed MSW compost @ 10 t ha^{-1} and T_8: PG @ 25% GR + industrial processed MSW compost @ 10 t ha^{-1} was conducted with three replications under Randomized Block Design. Rice and wheat crops were grown in Kharif and Rabi seasons and all the recommended agronomic practices were followed. Observations related to plant growth and yield were recorded. 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.

Results and Discussion

Physico-chemical and microbial changes 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). In our study, temperature ranges between 31.0 to 58.4°C. Maximum temperature was recorded in treatment T_7 and minimum with T_1 but the difference between the treatments was not significant (Fig. 1).This is because of having both MSW and agricultural wastes in equal ratio and enriched with earthworm and microbes. From the data it is evident that the moisture content under different treatment was unstable throughout the composting process and varied from 19.4% to 67.5. The highest moisture content (67.5%) at 15 DOC was recorded with treatment T_7 and

the lowest with T_1. After 30 days onward, the moisture content between the treatments did not show any stable trend in all the treatments. However, at maturity the moisture content in all the treatments was significantly reduced over the initial values (Fig. 1).

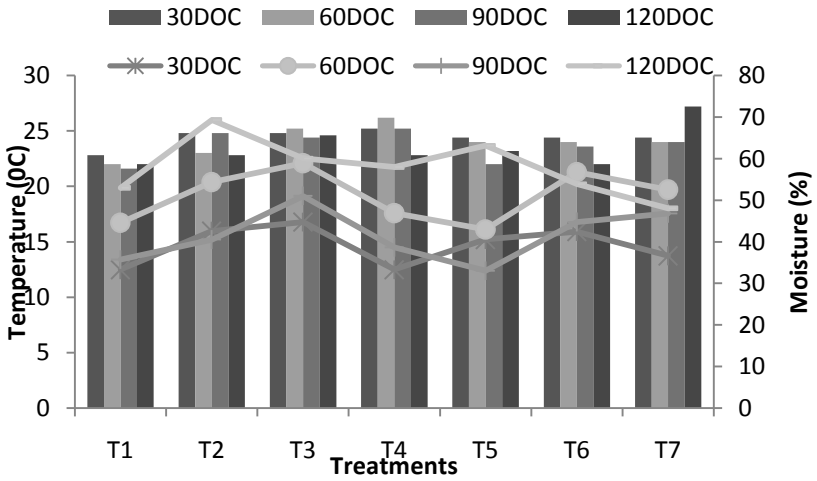

Fig.1. Changes in temperature and moisture content under different treatments during composting

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. The results indicate that the EC decreased with increasing the time (Fig. 2). At maturity, highest EC was recorded in the treatment T_6 where MSW was enriched with both microbes and earthworms and minimum with treatment T_3. The decline in EC may be because of more stable bond between ions and organic matter throughout composting (Moretti *et al.*, 2015).

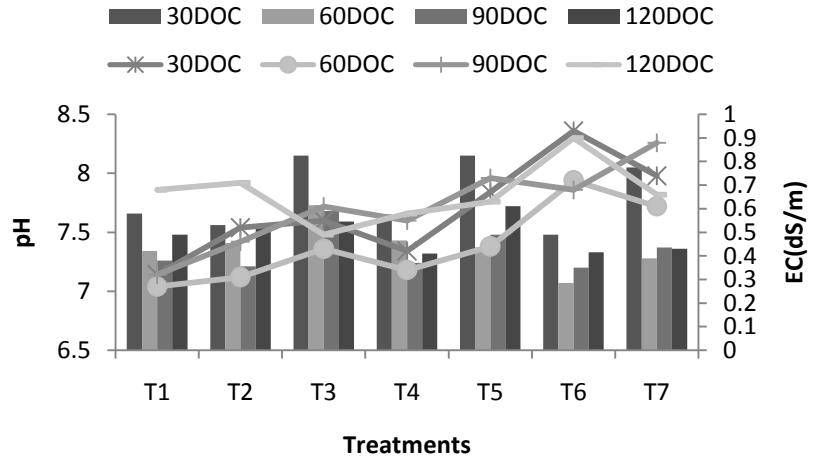

Fig. 2. Changes in pH and EC under different treatments during composting

The highest total nitrogen at initial stage was found in treatment T_3 and T_5 followed by the treatments T_2, T_4, T_6, T_7, and T_1 with 0.47, 0.46, 0.43, 0.42 and 0.40%,

respectively (Table 1). However, at maturity, highest total nitrogen was estimated in the treatment T_7 (0.79%) followed by the treatment T_6, T_3, T_5, T_2, T_4 and T_1 with 0.65, 0.58, 0.56, 0.51, 0.51 and 0.43%, respectively. Similar trend was observed in total P and total K content. At initial stage of composting, the highest total P (0.33%) was recorded in the treatment T_2 followed by the treatments T_5, T_7, T_3, T_4, T_6 and T_1 with 0.31, 0.31, 0.26, 0.26, 0.25 and 0.21%, respectively. At maturity it increased substantially in all the treatments and the approximately corresponding values varies between 0.39 to 0.41% (Table 1).

The highest total carbon content at initial stage of composting was found treatment T_7 whereas, lowest in T_4. However, at the maturity, the maximum total carbon content (13.69%) was recorded in treatments T_5 and minimum (11.14%) at T_1 where only MSW was used. The total carbon content decreased in all the treatments 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 (Siddiqui *et al.*, 2006).

Data given in Table 1, showed that the lowest C: N ratio at initial stage of composting was found in treatment T_4 (24.69%) whereas, at maturity lowest C: N ratio (17.13) was observed in treatment T_7 where 50% MSW and 50% agricultural wastes were enriched with both earthworm and decomposing microbes. The experimental analysis showed that the bacterial and fungal count (Cfu/g) was higher at initial stage and it gets reduced in all the treatments at the maturity. The highest population of bacteria and fungus at 30 and 120 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. Based on the above study it was concluded that treatment T_7 produced high quality compost in terms of it nutrient status and C: N ratio. This compost was used in the highly sodic soils (pH 9.8, EC 1.47) in combination with gypsum to monitor its effect on restoration of degraded sodic soils and crop productivity.

Soil improvement and crop productivity

Highest reduction in soil bulk density was recorded under treatment T_3 (gypsum @ 25% GR + on-farm MSW compost @10 Mg ha^{-1}) and lowest in T_1 (gypsum @ 50% GR). Nevertheless, application of gypsum alone, while being successful in improving soil properties significantly, does not have much effect on soil physical properties. Infiltration rate increased from 4.10 mm day^{-1} to 18.20 mm day^{-1}. Highest infiltration rate was recorded with treatment T_4 where phosphogypsum @ 25% GR and on-farm MSW compost @10 t ha^{-1} was applied (Table 2). It was observed that there was significant improvement in pH, EC, ESP, and organic carbon over the initial values. The soil pH ranged from 8.84 to 9.29 under different treatments. Maximum reduction in soil pH over the initial value was recorded in treatment T_3 whereas minimum in T_5.

Grain yield of rice and wheat was significantly higher with application of gypsum @50% GR and application of gypsum followed by MSWC over the control. 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 (Table 2).

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
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

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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कृषि उत्पादन में वृद्धि हेतु दक्ष जल संरक्षण तकनीकें

डॉ0 आशुतोष उपाध्याय

प्रधान वैज्ञानिक एवं प्रमुख, भूमि एवं जल प्रबंधन प्रभाग

भारतीय कृषि अनुसंधान परिषद का पूर्वी अनुसंधान परिसर, पटना

सारांश

भारत वर्ष में भूमि एवं जल प्रचुर मात्रा में उपलब्ध हैं। किन्तु बढ़ती हुई जनसंख्या का दवाब और मानव द्वारा अनावश्यक रूप से प्राकृतिक संसाधनों का दोहन करने के कारण प्रति व्यक्ति भूमि एवं जल की उपलब्धता घटी है। जल संसाधन की समृद्धता और निरंतर उपलब्धता बनाए रखने के लिए जल संरक्षण तकनीकों की जानकारी होना अनिवार्य है।इस पत्र में,ऐसी दस जल संरक्षण तकनीकों जो) प्रायोगिक प्रक्षेत्र में जाँची व परखी गई हैं,और जो सामाजिक रूप से स्वीकार्य, आर्थिक रूप से वहन योग्य, तकनीकी दृष्टि से व्यवहार्य , पर्यावरण के लिए हानिरहित , मनोवैज्ञानिक रूप से प्रभावशाली , आसानी से कार्यान्वित हो पाने वाली सरल , उत्तम व स्थायी हैं) का चयन करके काव्यात्मक रूप में प्रस्तुतीकरण किया गया है।

परिचय

जल कृषि उत्पादन में बहुत महत्वपूर्ण भूमिका अदा करता है। इसके बिना जीव जन्तु या वनस्पति में जीवन की कल्पना नहीं की जा सकती हैं। जल पृथ्वी पर पर्याप्त मात्रा में उपलब्ध था , परंतु निरंतर बढ़ती जनसंख्या के दवाब के कारण और जल के लिए कारखानों ,शहरी व घरेलू माँगों में बढ़त के कारण कृषि के लिए जल की उपलब्धता दिन प्रति दिन कम होती चली जा रही है। भारत विश्व के कुल भौगोलिक क्षेत्र का मात्र प्र 17 प्रतिशत है परंतु इस पर विश्व की लगभग 2.5तिशत आबादी तथा प्रतिशत पशुधन का बोझ है। एक आकलन के अनुसार 18, देश में उपयोग हेतु उपलब्ध जल संसाधन कुल उपलब्धता का लगभग प्रतिशत है। प्राचीन काल में भी जल के महत्व के पहचाना 4 गया था जैसा कि नारद स्मृति, एकादश," -में दृष्टिगोचर होता है 19 जल के बिना अन्न का एक दाना भी उत्पन्न नहीं हुआ , लेकिन जलाधिक्य से अनाज सड़ भी जाते हैं। अन्न की वृद्धि के लिए बाढ़ भी उतनी ही हानिकारक है जितना दुर्भिक्ष। आज करीब अस्सी देशों में निवास करने वाली विश्व की चालीस प्रतिशत आबादी जल के गंभीर संकट से जूझ रही है। अतजल का संरक्षण व : सदुपयोग करना अत्यन्त आवश्यक है, अन्यथा भविष्य में यह समस्या और विकराल रूप धर लेगी और आगे आने वाली पीढ़ियाँ हमको माफ नहीं करेंगी।यदि कुछ जल संरक्षण तकनीकों को कृषि में अपनाया जाये तो कम जल का सक्षम उपयोग कर अधिक कृषि उत्पादन प्राप्त किया जा सकता है। इस विषय पर मैंने काव्यात्मक शैली में अपनाने योग्य दस महत्वपूर्ण जल संरक्षणतकनीकों का चयन किया है , यह जल संरक्षण . जिनको अपनाकर किसान भाई जल संरक्षित करते हुए अपनी उपज बढ़ा सकते हैं -तकनीकें हैं

1. धान के खेत में मेडबंदी द्वारा वर्षा जल संरक्षण
2. नहर के कुशल प्रचालन रख ,रखाव व सहभागिता द्वारा जल संरक्षण

3. उचित पम्पिंग सेट व भूमि का चयन करके भू जल का सक्षम उपयोग करके जल संरक्षण
4. नहर व भूजल का संयुक्त उपयोग करके जल उत्पादकता में वृद्धि
5. खारे व मीठे जल का संयुक्त उपयोग करके जल संरक्षण व जल उत्पादकता में वृद्धि
6. जल संरक्षण के लिए उचित सिंचाई विधि का चयन
7. जल संरक्षण के लिए मल्चिंग या पलवार का उपयोग
8. बलुई व केवाल मिट्टी में सिंचाई के तरीके में परिवर्तन करके जल संरक्षण
9. लेज़र लेंड लेवलिंग द्वारा जल संरक्षण
10. जल का बहु आयामी उपयोग समेकित कृषि प्रणाली अपनाकर /जल संरक्षण

ये सभी जल संरक्षण तकनीकें वैज्ञानिकों द्वारा देश के विभिन्न स्थानों पर प्रयोग करके , सफलतापूर्वक सिद्ध की जा चुकी हैं और इनका न केवल जल संरक्षण वरन उत्पादन वृद्धि व जल तो प्रस्तुत हैं येजल संरक्षण तकनीकें काव्यात्मक शैली . उत्पादकता वृद्धि में अभूतपूर्व योगदान रहा है - में

(1)

जलतो है सीमित संसाधन, जल संरक्षण अपनाना होगा
कैसे हो जल का सदुपयोग, यह सबको समझाना होगा
भारत में विश्व के भूभाग का, है लगभग ढाई प्रतिशत
यहाँ निवास करती जनसंख्या, विश्व की सत्तरह प्रतिशत
और यहाँ पशुधन भी हैज्यादा, विश्व का अठारह प्रतिशत
पर सबके पोषण को उपलब्ध जल है, मात्र चार प्रतिशत
कितना दबाव इसजल पर है, यहसबको बतलाना होगा
जल तो है सीमित संसाधन, जल संरक्षण अपनाना होगा
कैसे हो जल का सदुपयोग, यह सबको समझाना होगा

(2)

वर्षा का पानी अनमोल, न बहने दें यूँ हीं बेकार
करें इसका भंडारण, दें तालाब पोखरों को आकार
धान का खेत भी है, वर्षा जल भंडारण का प्रकार
नौ इंच ऊंची मेड़ बनायें,करें वर्षा जल संचय साकार
धान की उपज बढ़ाकर, भूजल स्तर भी उठाना होगा
जल तो है सीमित संसाधन, जल संरक्षण अपनाना होगा
कैसे हो जलका सदुपयोग, यह सबको समझाना होगा

(3)

नहर का जलभी उत्पादन वृद्धि में,देता है अद्भुत योगदान
जब होता कुशल संचालन, प्रबंधक आवश्यकता का रखता ध्यान
सही समय पर उचित मात्रा में जल,उत्पादकता वृद्धि को वरदान
कम करने को नहर जलह्रास, उचित रखरखाव बस एक निदान
जल उपभोक्ताओं व प्रबंधकों के बीच, आपसी सहयोग बढाना होगा

जल तो है सीमित संसाधन, जल संरक्षण अपनाना होगा
कैसे हो जलका सदुपयोग, यह सबको समझाना होगा
(4)
भूजल ही जलका ऐसा स्रोत है, जो भूमि के नीचे छिपा हुआ है
कब, कितना, कहाँ, कैसे मिल सकेगा, इसका न सबको ज्ञान हुआ है
वैज्ञानिक बतायेंगे परीक्षण करके, किस ही भूमि का चयन हुआहै
और उचित पंप,पाइप, इंजन का जल आहरण में चुनाव हुआ है
भूजल बहुत कीमती है, इसका सक्षम उपयोग सिखलाना होगा
जल तो है सीमित संसाधन, जलसंरक्षण अपनाना होगा
कैसे हो जलका सदुपयोग, यह सबको समझाना होगा
(5)
वर्षा विलंब से होने पर, धान भी देर से रोपा जाता
धान पकता देर से, और गेहूँ विलंब से बोया जाता
समय से बीज न बोने से, फसलोत्पादन घट जाता
रोहिणी में नर्सरी लगाने से, भूजल उपयोग हो जाता
नहर भूजल संयुक्त उपयोग को, किसानों तक पहुँचाना होगा
जलतो है सीमित संसाधन, जल संरक्षण अपनाना होगा
कैसे हो जलका सदुपयोग, यह सबको समझाना होगा
(6)
खारे पानी से सिंचाई का मित्रों,फसलोत्पादन पर पड़ता दुष्प्रभाव
किसान फिर भी करते हैं सिंचाई, क्योंकि मीठे पानी का है अभाव
खारे और मीठे पानी को मिलाकर, सिंचाई से होगा अच्छा प्रभाव
फसलोत्पादन भी बढ़ जायेगा, और फसल का मिलेगा अच्छा भाव
खारे मीठे के संयुक्त उपयोग को, किसानों तक पहुँचाना होगा
जलतो है सीमित संसाधन, जलसंरक्षण अपनाना होगा
कैसे हो जलका सदुपयोग, यह सबको समझाना होगा
(7)
सिंचाई के हैं कई तरीके, कहाँ कौनसा तरीका उपयुक्त रहेगा
खेत की आकृति, ढाल, मिट्टी, मौसम एवं फसल यह तय करेगा
जल का स्रोत व उपलब्धता भी, सिंचाई विधि को प्रभावित करेगा
ड्रिप, स्प्रिंकलर और सोलर पंप से, जल का दक्षतापूर्ण उपयोग रहेगा
कैसे करें सही सिंचाई विधि का चुनाव, यह सबको बतलाना होगा
जल तो है सीमित संसाधन, जलसंरक्षण अपनाना होगा
कैसे हो जल का सदुपयोग, यह सबको समझाना होगा
(8)
मिट्टी में जल रहे संरक्षित, इसके करने होंगे प्रयास

वाष्पीकरण को रोकने का, मल्चिंग ही है उपाय खास
फसल अवशेष या प्लास्टिक बिछाने से, उगती नहीं है घास
पौधा भी अच्छा फलता है, क्योंकि जल रहता है आसपास
इसलिए मल्चिंग तकनीकी को, किसानों तक पहुँचाना होगा
जल तो है सीमित संसाधन, जलसंरक्षण अपनाना होगा
कैसे हो जल का सदुपयोग, यह सबको समझाना होगा

(9)

बलुई मिट्टी में मित्रों, जल का बहुत रिसाव होता है
और केवाल मिट्टी में जल, कम अवशोषित होता है
बलुई मिट्टी में कम, पर कई बार जल देना होता है
केवाल मिट्टी में ज्यादा, पर कम बार जल देना होता है
मिट्टी की किस्म के अनुसार जल प्रबंधन अपनाना होगा ,
जल तो है सीमित संसाधन, जलसंरक्षण अपनाना होगा
कैसे हो जल का सदुपयोग, यह सबको समझाना होगा

(10)

भूमि समतलीकरण द्वारा भी,जल ह्रास कम हो जाता है
फसल को मिलता बराबर पानी, उत्पादन भी बढ़ जाता है
लेज़र लेंड लेवलिंग लाभकारी है, अनुभव तो यही बताता है
जल की बचत और उत्पादन में वृद्धि, किसको नहीं सुहाता है
तो लेज़र लेंड लेवलिंग तकनीकी, किसानों तक पहुँचाना होगा
जल तो है सीमित संसाधन, जलसंरक्षण अपनाना होगा
कैसे हो जल का सदुपयोग, यह सबको समझाना होगा

(11)

केवल फसलोत्पादन से, जल उत्पादकता हो गई अल्प
इसको बढाने के लिए, अब तलाशने होंगे नये विकल्प
जलके कई बार उपयोग का, अब करना होगा संकल्प
मछली, मुर्गी, बत्तख पालन सह फल सब्जी उत्पादन प्रकल्प
जलके बहुआयामी उपयोग को, किसानों तक पहुंचाना होगा
जल तो है सीमित संसाधन, जलसंरक्षण अपनाना होगा
कैसे हो जल का सदुपयोग, यह सबको समझाना होगा

ABSTRACTS

Zero energy drip system for sustainable crop production in North Western Himalayas

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Sustainable agricultural production becomes an essential for humankind. Agriculture sector in India is highly dependent on rainfall. There is any variability of climate might be drastically reduces the agricultural production. Along with this, agriculture sector remains the largest user of water consumption i.e. accounting for more than 75% of water usage throughout the country. As per energy analysis of agricultural operations, a remarkable amount of energy is used for irrigation in contrast to other operations. Consequently, this is necessity to utilized scarce irrigation water efficiently and judiciously to improving productivity of vegetable crops through energy efficient water saving irrigation systems. Especially in Himalayan region, most of the agricultural area is depends on rainfall for its water requirement. It has been proved by experimentation that application of zero energy drip irrigation during moisture deficit period to vegetable crops can enhance productivity by 40-45%. Results revealed that the marketable yield of vegetable crops such as cabbage, tomato and okra were 130 kg, 120 kg and 60 kg, respectively. Whereas, total incomes were Rs. 1500, Rs. 1650 and Rs. 2380 from cabbage, tomato and okra crops, respectively. By using zero energy drip irrigation systems increased fruit yield of vegetable crops by 25-30% as compared to farmer practice in addition to saving of labour charges Rs. 2500/-per season.

Keywords: *Zero energy drip system; Low cost, Vegetable crops; Net return and Himalayas*

Bio-engineering measures for conservation of soil and water Resources in North Western Himalayas

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Declining agricultural productivity particularly in Himalayan regions as a result of intensive rainfall on steep slopes leads to generation of damaging runoff contributing high soil erosion and declining soil fertility. Present study focused on the impact of bio-engineering measures such as terraces and inters cultural practices in the northern western Himalaya regions to control the runoff, soil erosion and improve soil moisture availability along with soil fertility. A field experiment compared the soil moisture availability, reduction of runoff percentage and soil erosion rate of terrace field and non-terraced sloppy field. In terraced field, wheat and maize crops were grown and non-terraces field intercropping activities were performed as adopted by local farmer's practices. The highest runoff generation 63.21 % of total rainfall was recorded in non-terraced field where there were no intercultural practices was adopted. Lowest runoff generation 21.56 % was obtained in terraced field followed by non-terraced field with intercultural practices. The annual soil erosion was also followed the similar trend. The soil moisture availability was recorded highest in terraced based agriculture field and lowest was found in sloppy agricultural non-intercropping field. For the sustainability of the Himalayan region, terrace practices would be better option for controlling damaging runoff and soil erosion and also help to improves the soil moisture availability for better crop growth.

Keywords: *Terrace; Sloppy terrain; Soil erosion; Soil moisture and Indian Himalaya.*

Effect of Methods of Land Preparation on Growth and Yield of Transplanted Rice (O*ryza sativa*) in Canal Commands of North Western Plateau Agroclimatic Zone of Odisha - An on-Farm Study

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An on-Farm study conducted on a sandy clay loam soil of Pitamahal irrigation command, Sundargarh (Odisha) for two consecutive dry seasons of 2016-17 and 2017-18 on response of transplanted rice to methods of land preparation. The treatments comprised of three methods of land preparation such as normal ploughing with desi plow followed by leveling of 0.5 - 1% slope (T_1), deep ploughing (20 - 25 cm) with bullock drawn M.B. plow followed by leveling of 0 - 0.25% slope (T_2) and farmers practice of ploughing with desi plow & leveling varying 1- 3% slope (T_3) for puddling operation. Study revealed that deep ploughing (T_2) recorded higher length of root (23.88 cm) and root volume (81.75 cm^3) mainly due to initial rapid growth of roots facilitated by deep ploughing that broke the hard pan. This also encouraged water movement both laterally and vertically (7.44 mm day^{-1}) compared to 5.11 and 5.71 m day^{-1} due to T_1 and T_3, respectively. The treatment also showed significantly higher grain yield (41.88 q ha^{-1}) due to significantly higher effective tiller m^{-2} (473.40) and number of grains $panicle^{-1}$ (81.80) along with higher net return per rupee invested (4.38) and benefit-cost ratio (2.04).

Keywords: *Land leveling, transplanted rice, clay pan, root growth, seepage and percolation, yield, economics*

Subsurface drip irrigation for efficient fertilizer and water use in wheat crop- A case study

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Subsurface drip irrigation (SDI) is considered as one of the most accurate method for the application of water as well as fertilizers in the crop root zone. The present work involved evaluation of fertilizer use efficiency of wheat under subsurface drip irrigation. Fertigation was practiced at three different levels on 36 plots. The analysis of crop parameters was done in the mid-stage (40 days after sowing) and pre-harvest stage (90 days after sowing) and parameters such as plant height, tiller count, grains per spike, spike length, 1000 grain weight, grain and straw yield were estimated.Straw yield was observed significantly highest in treatment I_1F_1 (100 % ET_C; 100 % RDF), significantly lower yield was observed in no fertigation level (F_4). There was no significant difference in grain yield between I_1 and I_2, also between F_1 and F_2 treatments, but yields were significantly lower for deficit irrigation level, I_3 (60% ET_C) and deficit fertigation level, F_3 (60% RDF). Comparatively, in terms of economy of water and fertilizer, treatment (I_2F_2), presented better results, as both irrigation and fertigation is reduced by 20%. Maximum nitrogen concentration was observed in I_1F_1 treatment (100 % ET_C; 100 % RDF) with a value of 0.90% (2018-19) and 0.98 % (2019-20). There was significant decrease in nitrogen concentration in grain both with decrease in irrigation and fertigation, with highest value of 1.43% and lowest value of 0.50% in experimental year 2018-19. It could be concluded that there was no significant difference between I_1 F_1 and I_2 F_2 treatments whereas, significant difference was noted between I_1 F_1 and deficit irrigation I_3 and deficit fertigation F_3 treatments in most of the parameters. Economically I_2 F_2 treatment was observed to perform better in terms of both water and fertilizer requirement.

Keywords: *Subsurface drip irrigation, fertigation, irrigation scheduling, fertigation scheduling and CPCS1 software*

Fixed Bed Column Adsorption of Organic Pollutants Using CZnO Nano Based Adsorbent Coated Sand Filter Bed for Dairy Industrial Effluent Treatment

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Chitosan zinc oxide (CZnO) nano based adsorbent was synthesized by chemical precipitation method and characterized by using particle size analyzer, SEM-EDS, XRD, FT-IR, AFM and DSC. Individual and interactive effects of process parameters were studied using response surface methodology (RSM) coupled with Box-Behnken design (BBD). The comparative study between an artificial neural network (ANN) and response surface methodology (RSM) was done in the modelling and prediction of process parameters. The results indicate the superiority of a properly trained ANN in capturing the linear behaviour of the adsorbent and the simultaneous prediction of two outputs (BOD and COD). Maximum per cent reduction efficiency of BOD using chitosan zinc oxide coated sand (CZOCS) filter bed was found at optimized CZnO coating dosage of 1.5 M, contact time of 120 min, pH of 6 and initial concentration of 50 mg/L. Similarly, maximum per cent reduction efficiency of COD using CZOCS filter bed was found at optimized CZnO coating dosage of 1.5 M, contact time of 120 min, pH of 6 and initial concentration of 50 mg/L. Effect of filtration time and bed height on breakthrough points for BOD adsorption using CZOCS filter bed was found maximum breakthrough capacity (BTC) of 143.00 mg/g, exhaustion capacity (EC) of 143.50 mg/g and degree of column utilization (DCU) of 99.65% at 40 cm bed height. Effect of filtration time and bed height on breakthrough points for COD adsorption using CZOCS filter bed was resulted maximum BTC of 183.25 mg/g, EC of 185.75 mg/g and DCU of 98.65% at 40 cm bed height. Thomas model was found best fitted model for adsorption of BOD and COD using CSZOCS filter bed at 30 cm bed height.

Keywords: *Chitosan zinc oxide, Chitosan zinc oxide coated sand, Dairy industry, Effluent, Nano based adsorbent and Modeling*

Mid infrared spectroscopy: a new technological and alternate option to conventional lab analysis for soil quality assessment

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The demand for suitable soil quality indicators for evaluating and monitoring the impact and measuring the success of specific agricultural practices has increased. The frequent and excessive use of chemical fertilizer has created problems like deterioration of soil quality and ecology. Hence, soil quality estimation is one of the most important means of evaluating changes in soil resulting from land management. In general different soil properties like physical, chemical and biological are estimated through routine conventional laboratory analysis which are usually costly, labour intensive, time consuming and also utilizes many chemicals not friendly to the environment. Spectroscopy in the mid-infrared (MIR) region (approximately 4000 to 400 cm^{-1}) is one of the most important analytical techniques available for gathering information about qualitative and quantitative aspects of analytics with high accuracy in short time. Mid infrared Spectroscopy is rapid, timely, less expensive, non-destructive, straight-forward, sometimes more accurate than conventional analysis and do not use any toxic chemical. Furthermore, a single spectrum is enough for simultaneous characterization of various soil properties. The strength of Mid infrared spectroscopy (MIRS) lies in its ability to provide rapid and cost effective estimates of a number of physical and chemical and biological properties of soil. Many potential and actual applications for MIR analysis are possible in either commercial soil testing. These include: soil analysis, decision support, soil classification, soil survey and mapping precision agriculture, diagnosis of soil problems, contaminated soil characterization and management, input data for models and as a replacement for pedotransfer functions. Out of several important advantages of MIR few are like, i) high precision ii) very fast, it takes approximately 30sec to scan a sample. The instrument can scan many samples within a short time iii) It is cheap, no sample preparation using chemical reagents is required also it is non-destructive analysis. Finally for environmental monitoring, climate change modelling and precision agriculture nowadays there is a great demand for larger amounts of good quality and inexpensive soil data. Large number of sample analysis at a short period is imperative for site-specific nutrient management. So, there is a global thrust towards the development of less time and cost efficient technologies like Mid infrared spectroscopy (MIRS) for accurate soil quality analysis.

Keywords: *Soil quality, Mid infrared spectroscopy (MIRS), coefficient of determination (R2), root mean square error (RMSE), residual prediction validation (RPD)*

Studies on the effect of water regimes and organics on water saving, soil fertility and yield of rice (*Oryza sativa* L.)

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Field experiment was conducted at Soil and Water Management Research Institute, Kattuthottam, Thanjavur during navarai seasons of 2017 - 2018 to study the effect of water regimes and organics on water saving, soil fertility and yield of rice. The field experiment was laid out in split plot design with three replications. The experiment consisted of three water regimes viz., Irrigation on the da disappearance of ponded water (M1), Irrigation on two days after disappearance of ponded water (M2), Irrigation on five days after disappearance of ponded water (M3) in main plots and six sub plots treatments viz., control (Absolute) (S1), green manure@ 6.25 t ha^{-1} (S2), farm yard manure @ 12.5 t ha^{-1} (S3), vermicompost @ 5 t ha^{-1} (S4), coir pith compost @ 12.5t ha^{-1} (S5), poultry manure @ 5t ha^{-1} (S6). Water regimes and organics significantly influenced water saving, nutrient uptake by rice, physical, chemical properties of soil, yield and economics of rice. Water regimes and organics considerably influenced the growth and yield of rice. The maximum values of growth traits were recorded under the irrigation on the day of disappearance of ponded water. Among organics, the maximum values of growth traits and better yield attributes were encountered in poultry manure @ 5 t ha^{-1}. Among interactions, significantly superior growth and yield parameters were recorded with irrigation on the day disappearance of ponded water with poultry manure @ 5 t ha^{-1}. Irrigation on five days after of disappearance of ponded water with control (Absolute) registered significantly lower growth and yield attributes. Irrigation on the day disappearance of ponded water recorded significantly higher grain and straw yield (4564 and 5705 kg ha^{-1} respectively), which was followed by irrigation on two days after disappearance of ponded water with 4229 kg ha^{-1} of grain yield and 5286 kg ha^{-1} of straw yield, whereas irrigation on five days after disappearance of ponded water recorded lower grain and straw yield (3784 and 47391 kg ha^{-1}respectively). Poultry manure @ 5 t ha^{-1} registered higher grain and straw yield (4789 and 5940 kg ha^{-1} respectively), which was followed by green manure @ 6.25 t ha^{-1} (4602 and 5753 kg ha^{-1}). Control (Absolute) registered lower grain and straw yield (2523 and 3154 kg ha^{-1} respectively). Irrigation on the day disappearance of ponded water with poultry manure @ 5 t ha^{-1} registered higher grain and straw yield (5332 and 6665 kg ha^{-1}respectively), which was followed by irrigation on the day disappearance of ponded water with green manure @ 6.25 t ha^{-1} (4980 and 6225 kg ha^{-1}). Based on the experimental results, it can be concluded that in sandy loam soil of new Cauvery delta zone, rice with irrigation on the day disappearance of ponded water with poultry manure @ 5 t ha^{-1} was found better in terms of higher grain yield and net returns and could be viable when the resources are abundant. Irrigation on two days after disappearance of ponded water with poultry manure @ 5 t ha^{-1}

Keywords: *Rice, Water regimes, Organics, Water saving and Yield*

Assessment of Decadal Variability in Land use/Land cover using remote sensing and GIS

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Proper knowledge about natural and manmade land feature has tremendous effect for effective management of natural resources. This article presents an enhanced temporal change in land use and land cover in Kaimur district, Bihar. Satellite images for the years 1990, 2000, 2010 and 2020 were used for Normalized Difference Vegetation Index (NDVI) classification techniques, five NDVI classes were decided: water bodies and barren land, Fallow land, vegetation land crop, agroforestry, deep forest. Initially, visible and near-infrared bands of Landsat 8 satellite were used to derive Normalized Different Vegetation Index. NDVI method is applied according to its characteristic like vegetation at different NDVI threshold values such as 0.24-0.05, 0.05–0.19, 0.19–0.28, 0.28–0.36 and 0.36–0.57. Simulated results show that the NDVI is highly useful for detecting the surface features of the visible area which are extremely beneficial for policymakers in decision making. The Vegetation analysis can help to predict the unfortunate natural disasters to provide humanitarian aid, damage assessment and device new protection strategies. From the empirical study, the forest, fallow land and Agroforestry cover types have decreased by about 13.9 %, 4.7 % and 7.2 % respectively from 1990 to 2020, while vegetation land crop has increased by 19.7 % and water bodies and barren land have increased by about 11 %. Classification techniques are very useful in sustainable development and change detection, as done for the Kaimur district can be done for similar regions of the country.

Keywords: *NDVI, Remote Sensing, Landsat images, Temporal Change Detection, Kaimur*

Productivity of lowland rainfed rice (*Oryza sativa*) as influenced by establishment and weed management

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Field experiments were conducted during the kharif seasons of 2016 and 2017 in the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus to evaluate the efficacy of various weed management practices in different rice establishment methods for improving rice productivity through weed control. The experiment was laid out in split plot design with three stand establishment methods, viz. System of Rice Intensification (SRI), Integrated Crop Management (ICM) and Conventional Transplanting (CTR) in main plots and six weed management methods viz. weedy check, hand weeding (HW) at 20 and 40 days after transplanting (DAT), bispyribac sodium @ 0.25 l ha^{-1} at 20 DAT , pretilachlor @ 1 l ha^{-1} at 3 DAT followed by (fb) one HW at 40 DAT, pretilachlor @ 1 l ha^{-1} at 3 DAT fb Bispyribac Sodium @ 0.25 l ha^{-1} at 20 DAT and cono weeding at 20 and 40 DAT in sub-plots. Results revealed minimum weed density (83.5 m^{-2}) and weed dry matter (158 g m^{-2}) in ICM while maximum was observed in SRI. Same trend was observed in case of grasses, sedges and broad leaved weeds. Significantly lower weed density (54.7 m^{-2}) and weed dry matter (103 g m^{-2}) was observed under HW twice at 20 and 40 DAT among the weed management methods. SRI gave better crop growth i.e plant height, number of tillers and crop biomass $hill^{-1}$ and yield attributes such as panicles m^{-2}, grains per panicle and harvest index as compared to the other establishment methods. In terms of grain yield, SRI (4.24 t ha^{-1}) and ICM (4.05 t ha^{-1}) produced 17.5 and 12.2% higher grain yield respectively over CTR. Among the weed management methods, hand weeding at 20 and 40 DAT (4.59 t ha^{-1}) recorded 81% higher grain yield of rice over control. The highest BC ratio (1.12) was obtained under SRI among establishment methods while application of pretilachlor @ 1 l ha^{-1} at 3 DAT fb Bispyribac Sodium @ 0.25 l ha^{-1} at 20 DAT recorded maximum benefit cost (BC) ratio (1.36) among the weed management methods.

Keywords: *Establishment method, weed management, productivity, BC ratio*

Influence of organic manures and bio-fertilizers with levels of nitrogen and phosphorus on Soybean

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A Field expriment on influence of organic manures and bio-fertilizers with levels of nitrogen and phosphorus on Soybean was conducted during *kharif* 2015 at Tribal Research cum Training Centre, Anand Agricultural University, Devagadh Baria, Dist. Dahod, Gujarat. The experiment consisted of sixteen treatment combinations each of two organic manures (vermicompost @ 2.5 t ha^{-1} and FYM @10 t ha^{-1}), levels of nitrogen (22.5 and 45 kg N ha^{-1}), levels of phosphorus (30 and 60 kg P_2O_5 ha^{-1}) and biofertilizers (No biofertilizer and *Rhizobium* + PSB). The experiment was laid out in randomized block design with factorial concept. The soybean variety NRC-37 was used in the experiment as a test crop. Significantly the highest seed yield (2100 kg ha^{-1}, 2096 kg ha^{-1} and 2130 kg ha^{-1}) of soybean was found with the application of 45 kg N ha^{-1}, 60 kg P_2O_5 and seed treatment of *Rhizobium* + PSB, respectively.

Keywords: *Establishment method, weed management, productivity, BC ratio*

Deficit Irrigation: for Reducing Agricultural Water Use

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Deficit irrigation refers to the application of water below full crop water requirement. It is an optimizing strategy under which crops are deliberately allowed to sustain some degree of water deficit and yield reduction. The expectation is that any yield reduction will be insignificant compared with the benefits gained through diverting the saved water to irrigate other crops. The objectives of DI is to increase the WUE of a crop by eliminating irrigation that have little impact on yield, reduce the amount of water used for irrigating crops and improve the response of plants to certain degree of water deficit in a positive manner. Main approaches in deficit irrigation includes, regulated / reduced deficit irrigation (RDI), partial root zone drying (PRD) and sustained deficit irrigation (SDI). RDI is a growth stage-based deficit irrigation strategy. The basic principle of this approach is that plant's demand to water stress, may not be equal in all the growth stages. Here the less irrigation applied to the non-critical stages of the plant may not cause a significant negative impact on plant productivity even though it may reduce normal plant growth. PRD involves irrigating only one part of the root zone in each irrigation event, leaving another part to remain dry for a certain degree. Two approaches of PRD are alternate partial root zone irrigation and fixed partial root zone irrigation. Sustained deficit irrigation is application of a certain degree of constant water stress throughout crop growth, without considering its phenological period. Subsurface irrigation is also considered as one of the DI practices which is used mainly in nursery systems and to a lesser extent, in the production of large-scale field crops. In this method the above portion of root zone is kept dry. Irrigation water is supplied to plants by capillary movement from the bottom. Deficit irrigation is scheduled based on the yield response factor of each crops with seasonal and specific growth stages. The basic rules for implementing deficit irrigation methods are practicing DI on relatively deep soils, use of drought resistant crops and varieties, increasing the contribution of precipitation, applying in the least sensitive growth stages, satisfying pre plant irrigation requirement, reducing irrigation losses and modifying cultural practices. The advantages of deficit irrigation are increased water use efficiency, enhanced root activity, improved nutrient use efficiency, improved product quality and increased plant yield. As world's population is expected to increase in future, the additional food required to feed future generations is under enormous pressure and thus the fresh water sources also. Therefore, each drop of water is precious and has to be used efficiently. Deficit irrigation practice combined with other advanced agronomic practices like mulching, cover cropping, no-tillage, ridge-furrow planting can enhance water productivity.

Keywords: *Water deficit, deficit irrigation scheduling, partial root zone drying, WUE*

Performance of artificial recharge structures in enhancing groundwater quantity

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Artificial recharge techniques are used to recharge the groundwater resources which are exploited by pumping for irrigation and domestic purposes. Artificial recharge structures are used in the hard rock regions of Tamil Nadu for groundwater restoration and management. The effectiveness of groundwater recharge structures in improving the recharge process has been evaluated for different recharge structures, namely, check dams and recharge borewells. The artificial recharge due to recharge structures during the northeast monsoon for a period upto December is about 11.4 per cent and during the southwest monsoon for a period upto September is about 15.6 per cent. Natural recharge, depth of increase in groundwater ranges from 1.1 to 1.5 m below ground level whereas the areas having artificial recharge structures the increase in groundwater table ranges from 1.3 to 5.3 m below ground level. The volume of water recharging ranges from 2100 to 3100 m^3 in check dams and 3200 to 4000 m^3 in recharge borewells. The zone of influence of check dam was 650-700 m and recharge borewells was 900-1100 m. The recharge rate of a check dam and recharge borewell were estimated as 0.27 m^3/m^2 of ponding area/month and 0.51 m^3/m^2 of ponding area/month respectively. The recharge borewell was found to be more effective in recharging the groundwater when compared to check dam.

Keywords: *Artificial recharge; Check dam; Groundwater level; Recharge borewell*

Customized automated fertigation system for soilless media in protected cultivation

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In recent years, the production of vegetables, flowers, and spices has been experiencing accelerated growth in protected cultivation. This can be achieved by application of water and nutrients through drip fertigation. In the conventional drip irrigation system, the farmer has to keep watch on irrigation and fertigation timetable, which is different for different crops. Advantage of automatic drip fertigation system is that the nutrient will take place only when there will be intense requirement for them. It promises the application of water in right quantity along with right fertilizer at right time, thereby reducing fertilizer loss and labour resulting in saving of money with the help of an automated mechanism. An automatic control system was developed for real time preparation and application of nutrient solution cucumber cultivation in soilless culture under greenhouse conditions. This system uses an EC and pH sensor to automatically check the concentration level of the nutrient solution. The commercial crop yield was 4.74 kg m2 and the average total soluble solids of cucumber fruits was 4.50 Brix. Water use efficiency for tomato crop cultivated with the developed control system was 17.94 kg m^3. To produce 1 kg of cucumber fruits, 34.42 L of nutrient solution were necessary. The proposed system was efficient in adjusting the frequency of fertigation cycles and controlling the prepared nutrient solution concentration, minimizing environmental problems related to effluent disposal and contributing to economy of fertilizer and water resources.

Keywords: *Automated, Fertigation, Mechanism, Nutrient solution, Environmental hazards*

Inherent fertility of Ratte Khera farm of Punjab Agricultural University, Punjab, India

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To judge the micro and macro nutrients along with physico-chemical properties of Ratte-Khera farm of Punjab Agricultural University (PAU), Ludhiana, Punjab, India, present study was planned by collecting twenty four soil samples from eight different location using GPS during 2019 upto 90 cm. Parker nutrient index also evaluated for different nutrients for the region. Surface soil sample analysis revealed that 87.5% of the samples had normal pH (6.5 -8.7) and 12.5% soils were with pH varying between 8.8 to 9.3. Further, samples had electrical conductivity (EC >0.8 m mhos cm^{-1}, lower range of soil organic carbon (SOC) content (SOC<0.4%) and higher range of available potassium (K). About 87.5 and 12.5% soil samples were categorized as low and higher in available-phosphorus (P), respectively. All the surface samples had lower and higher range of DTPA zinc (Zn) and copper (Cu), respectively while 25 and 37.5% samples with lower range of DTPA iron (Fe) and manganese (Mn). Correlation analysis revealed that OC (%) content increase the availability of Fe, Zn, P and Mn and higher EC increase the availability of Fe and Zn while lower pH value increase the availability of P, Fe and Cu. Further, availability of Fe is positively associated with Mn, P, Cu and Zn in the soil. Parker nutrient index (PNI) values for SOC (1.13) and available-P (1.375) were in lower range, respectively while available K (3.00) was observed to be in higher range. Digital soil maps delineated the special variations of physic-chemical properties *viz.* pH, EC, OC (%) and different nutrients viz. available P, K, Zn, Mn, Fe and CU, respectively at the farm. Soil test based fertilization is recommended to meet the plant nutrient requirements to have enhanced crop productivity. Our analysis revealed that Ratte-Khera soils reported to be saline (white alkali soils) with normal pH (no need to add any gypsum or lime). Final recommendation is to apply 25% higher dose of nitrogenous (N) and phosphatic (P) fertilizers with no need for potassic fertilizers. Further, spatial deficiencies reported for Fe (spots E, F), Mn (spots A, E and F) indicating their recommended sprays along with Zn sprays.

Keywords: *Parker nutrient index, Soil fertility, Ratte-Khera, Macro-nutrients, Micro-nutrients*

Drip irrigation as one of the innovative techniques to conserve water and increase the productivity in sweet cherry

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Management of water has now became one of the important concerns of agriculture. Finding the techniques and the methods for the efficient utilization of water is critical for the success of agriculture/farming in the future. Precision agriculture technologies are finding their way into many facets of farming. Precision irrigation is one such technique that uses water wisely and help farmers to achieve the higher levels of crop yield in a minimal amount of water. Drip irrigation is a type of precision/ micro irrigation that plays a vital role in conserving the water and increasing the crop productivity by efficiently utilizing each and every single drop of water. A huge percentage of orchards in our country and particularly in Jammu and Kashmir are without any irrigation facilities therefore rainfall is the only source of moisture available to the plants. Hence water is not available to the plants during the critical stages of their growth and development, which leads to their poor yield and inferior fruit quality. Also the majority of the orchardists in Jammu and Kashmir practice the traditional flooding system of irrigation to irrigate their orchards resulting in a huge loss of water besides its adverse effects on growth of the tree and quality of the fruit. In Kashmir Sweet cherry is mainly grown on Karewas which are totally rain fed with poor water holding capacity. Very meagre amount of rainfall (~700 mm) coupled with its erratic distribution results in deficient water supply at fruit development stage which causes severe problems like poor fruit set, low productivity and inferior fruit quality that ultimately gets reflected by striking drop in economic well being of farmers. Drip irrigation can play an important role in increasing the yield and water use efficiency in sweet cherry by applying the right amount of water at the right time in the right place. Thus precision irrigation through drip can help the farmers to tackle the challenges like drought, evaporation, salinization, groundwater depletion and lack of access to water reserves by changing the way we use water.

Keywords: *drip irrigation, precision agriculture, productivity, sweet cherry, water conservation*

Effect of soil and foliar application of manganese on wheat cultivars and manganese transformation in soil

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A pot experiment was conducted during *rabi* 2018 to investigate the effect of manganese and organic manures (farmyard manure, FYM; poultry manure, PM) application on growth parameters and productivity of wheat cultivars (PBW 725 and PDW 314), Mn-fractions. Treatments consisted of soil and foliar application of manganese sulphate ($MnSO_4$) (25 and 50 ppm), either alone or conjointly with FYM and PM (0.5%). Soil application of $MnSO_4$ either alone or conjointly with organic manures significantly increased the concentration of DTPA-Mn and other Mn fractions of variable solubility in soil. The conjoint application of $MnSO_4$ and manures (FYM +PM) significantly increased the concentration of total-Mn, water soluble and exchangeable-Mn (WSEX-Mn), specifically adsorbed-Mn (Sp-Ad-Mn), oxide bound-Mn (Ox-Mn), amorphous (AFeOX-Mn) and crystalline iron oxide bound-Mn (CFeOX-Mn), organic matter bund-Mn (OM-Mn) and residual-Mn. Regardless of the treatments, OM-Mn was the smallest (~1% of total-Mn), while residual-Mn (~66% of total-Mn) was the largest Mn fraction. The relative preponderance of occurrence of different Mn fractions in soil followed an order: OM-Mn<SpAd-Mn<WSEX-Mn<Ox-Mn<AFeOX-Mn<CFeOX-Mn< residual-Mn. Manganese application significantly increased the number of effective tillers pot^{-1}, $grainear^{-1}$, ear length, grain and straw yield pot^{-1}, due to increased Mn concentration and uptake by grain and straw. The DTPA-Mn was significantly related to different Mn fractions, indicating that these fractions were in dynamic equilibrium with each other and governed Mn availability in soil.

Keywords: *Mn- fractions, organic manures, wheat cultivar, yield and yield attributes*

Pit method an option for vegetable production in waterlogged sodic soils

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Canal irrigation has played an important role for making India self sufficient in food grain production. India has large networks of unlined canals. Over irrigation and excessive seepage from canals had resulted extensive waterlogging and salinity problem in the country. About 6.73 million hectare of land is suffering with salt accumulation problem in India. Uttar Pradesh had more than 1.32 million hectare of sodic land resulting to huge loss of agricultural productivity. Nearly 10 to 15% canal irrigated sodic lands suffer with twin problems of shallow water table and sodicity. Waterlogged sodic soils could not be reclaimed by traditional gypsum based technology. Pond Based Integrated Farming System (PBIFS) Model has potential to reclaim waterlogged sodic soils assuring high returns with minimum payback period. The model could not be implemented over small areas less than 1000 m^2. Pit Method coupled with localized irrigation could be considered as an option to bring back waterlogged sodic soils to cultivation of vegetables and creepers. An experiment was conducted over an area of 40 m^2 by digging pits of size 0.50 m x 0.50 m x 0.50 m with 2.0 m effective spacing between the pits. Pits were filled with compost, water hyacinth and canal silt. Bottle gourds, pumpkins and sponge gourd were planted in pits. Localised irrigation was advised to the farmers to keep the salt movement outwards. The planting was done during the month of March. Total productivity of bottle gourd, sponge gourd and pumpkin were 60 q/ha, 50 q/ha and 25 q/ha resulting total productivity of 135 q/ha. The gross return of the produce was calculated as Rs 2.025 lakh/ha. Expenditure on account of labour charges was Rs. 50000.00/ha. The cost of irrigation was worked out as Rs. 10000.00 and seed and input cost was worked out Rs. 3500.00. The net returns comes out to be 1.39 lakh/ha. The method seems to be quite good for small piece of waterlogged sodic soils for vegetable production during dry period for nutritional and economic support of the poor farmers.

Keywords: *Canal command, Integrated farming system, Sodicity, Subsurface drainage, Waterlogging*

Assessment of Ground Water Quality for Irrigation Purpose in Bathinda District (Punjab, India)

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Water quality assessment and mapping should be carried out on regular basis for precise and planned application of the input. The information on the quality of ground water also indicates their possible effects on physico-chemical properties of soil and crop productivity. In this context the present study was under taken to assess the ground water quality parameters for irrigation purpose. Georeferenced ground water samples were collected from different blocks of Bathinda district, Punjab and analysed for different quality parameters i.e. pH, Electrical Conductivity (EC), Carbonate and Bicarbonate (CO_3^{2-}, HCO_3^-), Chloride (Cl^-), Total Hardness (Ca^{2+}+Mg^{2+}) and Sodium (Na^+) content; and Residual Sodium Carbonate (RSC) was calculated. Salinity and alkalinity hazards were evaluated using national and international standards and the overall, water quality was assessed to judge its suitability for irrigation purpose. EC, pH and RSC of ground water samples varied widely in different blocks of the districts. pH ranged from 7.21 to 9.08, EC from 0.1 to 21.2 dSm^{-1} and RSC from -14.33 to 10. Among the 257 irrigation water samples collected from eight blocks of Bathinda district, 57.2% samples were of marginal quality which can be used for irrigation purpose after certain amelioration. 24.12% samples were of good quality that can be efficiently for irrigation without any treatment; and rest 18.68% samples were of poor quality which is not suitable for irrigation purpose. The good quality of ground water samples were collected mostly from Rampura, Nathana and Bhakta Bhai Ka blocks representing 44%, 70.83% and 45.83% of the samples collected from the respective blocks. On the other hand, none of the samples was of good quality in Maur block. Finally water quality map was generated in ArcGIS using Kriging method indicating the ground water quality for irrigation purpose in different blocks of the district.

Keywords: *ground water quality, irrigation, GIS, Bathinda*

Conversion of line source saturated front to square source saturated front for measurement of unsaturated hydraulic conductivity

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Gardener's unsaturated hydraulic conductivity function is required for designing of drip irrigation systems. A line-source field dripper steady-state solution of Warrick (1985) had been used for in-situ measurement of Gardener's unsaturated hydraulic conductivity function of the soil. A large line segment may require huge volume of water for conducting field experiment. A small line segment may create a squire saturated front around the line source and may require significantly less amount of water. Therefore, a line source field dripper method was transformed to a small line segment source creating a square saturated front for in-situ measurement of unsaturated hydraulic conductivity function. The line source solution is given as below.

$$q_l = K_s x_S + \frac{3K_s}{4\alpha} \quad (1)$$

Where q_l is line source field dripper discharge rate, K_s is saturated hydraulic conductivity of the soil, x_s is the half width of saturated front and α is relative measurement of capillarity over gravity. The solution developed for line segment square saturated front of filed dripper with a correction factor (μ_c) is given as below.

$$q_p = K_s * x_s + \mu_c \frac{3}{4}\frac{K_s}{\alpha}\frac{1}{x_s} \quad (2)$$

An experiment was conducted over recently tilled normal soil to observe saturated front widths against applied line source discharges of 109.5, 127.8, 164.3 and 273.8 $cm^3/cm/hr$, respectively. Line source discharge was plotted against saturated front widths and inverse of saturated front widths. The slope and intercepts of the lines were worked out. Saturated hydraulic conductivity and relative measurement of capillarity over gravity were worked out using slopes and intercepts of lines. A line-source field dripper method resulted the value of saturated hydraulic conductivity as 8.146 cm/hr and α as 0.219 cm^{-1} while K_s value obtained from proposed method was 8.468 cm/hr and α as 0.219 cm^{-1}. The correction factor (μ_c) was taken as 0.393. The K_s and α values obtained by line-source method was almost identical to the proposed method. The proposed method is quick and water saving hence may be used for wider field applications.

Keywords: *Liner source, unsaturated hydraulic conductivity, field dripper & saturated front*

Mitigating Leaching Loss of Calcium through Foliar Nutrition

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The recent floods in Kerala has depleted and left the soil in its worst state. As soil nutrients have been washed away, it is very difficult to regain the lost glory of soil health. Cultivation of crops on this soil will be a myth unless some urgent management practices are done. The mobile elements like nitrogen, phosphorous and potassium can be easily made available in soil after application of fertilisers but this is not the case of immobile yet major element like calcium. In Kerala about 45 per cent of the soil is calcium deficient, because Ca^{2+} are not strongly adsorbed by the soil colloids and lost by leaching. Calcium deficiency is caused due to low calcium availability as it cannot be mobilized from older tissues and redistributed via phloem and hence must be supplied continuously. Since the time lag between applying nutrients and getting it available to crops is large, farmers can't lean towards conventional methods of soil application. The significance of foliar nutrition is highlighted there. Foliar nutrition is the technique of feeding plants by applying water soluble fertilizers directly to the leaves. The effectiveness of nutrient uptake is ten folds higher than conventional methods of plant nutrition. It has merits like low requirement, higher efficiency, least amount of nutrient loss, easy to apply, deficiency symptoms can be easily rectified and relatively immobile nutrients can be easily reached to photosynthetic area. Therefore, treatment of aerial plant parts with calcium sprays is recommended. Calcium is so important for the soil health as it prevents the growth of soil borne fungal pathogens, excess acidity of soil and dispersion of the monovalent clay particles in soil. It is a secondary essential macro nutrient which are less mobile in soil and immobile in plants. It plays a fundamental role in maintaining the structure and permeability of the cell membrane. It is essential for cell elongation and division. Even a temporary shortage of calcium can cause the development of deformed leaves and leads to production of low-quality fruit and result in economic losses caused by storage disorders. Calcium exerts beneficial effect on plant vigour and stiffness of straw and on grain and seed formation in cereals. Calcium preserves the fruits from deterioration by regulating respiration rate and minimizing ethylene evolution from tender fruits thereby conserving moisture content. Application of calcium as calcium chloride 0.5 per cent through foliar feeding enriched the calcium level of fruits, produced higher yield and assisted in reducing post-harvest losses. Foliar application of 0.406 per cent calcium nitrate at flowering stage significantly increased the grain yield of cereals. Preharvest spray of calcium nitrate ten days before harvesting of grapes enabled their storage for six days. Thus, calcium foliar nutrition serves as an effective tool in correcting calcium deficiencies and efficiently supply nutrients when the physiological efficiency of plant to take nutrients from soil is hampered.

Keywords: *Calcium; foliar nutrition; flood; rebuilding; crop; deficiency*

Effect of Different Mulches on Growth, Yield and Quality of Banana CV. Grand Naine

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Any material spread on the soil surface to protect it from solar radiation or evaporation is called mulch. Mulching in general is a beneficial practice for crop production. Mulch conserves soil moisture, retains heat as well as it suppresses weed growth. Mulching reduces the water evaporation rate and soil thermal regime during the day time. Mulches reduce weed population considerably and organic mulches improve microbial activity of the soil around the root zone. Hence, the present study was undertaken to know the effect of different mulches on the vegetative growth, yield and quality of banana cv. grand naine at horticultural research station, Aswaraopet during 2017-2020 seasons. Under the study different mulching treatments (black polyethylene mulch, organic mulch and without mulch) were used to record the vegetative growth measurements, bunch weight, yield and fruit quality of first and second ratoons of banana cv. grand naine. Based on three years research it can be conclude that, maximum yield was recorded with organic mulch (49.92 t/ha) by increasing the number of fruits per bunch (112.82), bunch weight (20.22 kg) fruit weight (194.39 gm) and vegetative parameters viz., maximum number of leaves per plant (25.93),leaf area (9.93 m^2) over control. Whereas both the mulches did not significantly influence the fruit TSS and shelf life parameters.

Keywords: *Mulch, Organic, Black polythene, Banana and grand naine.*

Prediction of evapotranspiration using pan evaporation based geometrical similarity model

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Transpiration of plants depends on plant species and weather parameters. Waterlogging, soil and water salinity also govern evapo-transpirative demand of the plant. Thus, the transpiration rate is influenced by crop characteristics, environmental aspects and cultivation practices. Evaporation and transpiration together referred as evapotranspiration (ET). Water management of the crops and trees requires basic understanding of ET. Measurement and modeling of ET for short duration crops is easier as compared to the long duration perennial crops, growing plantation and trees. Exotic crops or tree plantation are grown for draining of excessive soil and or ground water and known as bio drainage. Eucalyptus can grow well under salt and waterlogging conditions and widely recommended for bio-drainage in Indian subcontinent because of its high evapo-transpirative demand. Measurement of ET of growing trees is difficult and time consuming at various locations. Modelling of ET using weather parameters would be a good option for varying ecological conditions. The ET demands of growing tree or plants are required for designing ground water draft due to plantation over a long period of time. The method could be useful for design of bio drainage system for reclamation and management of waterlogged salt affected soils. Method of estimation of ET of tall growing tree suitable for bio drainage over a long period of time using simple weather parameter is still missing. Modeling of ET may avoid associated complexity of direct ET measurement. ET of tree or plant is dependent on interrelated weather parameters and age of the tree. A geometrical similarity (GS) between weather parameters (E_{pan}) and ET of plants were observed and a GS Model was hypothesized. Modeled ET of eucalyptus with a recently developed height based analytical model over a period of 10 years was used to work out monthly characteristic constants ($C_{Epan)}$ of GS Model. ET values predicted by GS Model for year 2004, 2008 and 2013 were compared with the modeled values of ET of different months. Overall average per cent deviation of predicted ET values by GS Model was only 12.66% compared to the analytically modeled ET values. GS Model has is a simple method for estimation of ET of large growing trees having great field applicability.

Keywords: *Bio drainage, Evapotranspiration, Geometrical similarity, Waterlogging*

Remote Sensing and GIS based Quantitative Morphometric Analysis of Thirteen Sub-Watersheds of Mand Catchment Chhattisgarh using SRTM-DEM

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Remote sensing and GIS are efficient techniques for the development of integrated land and water resources at grass root level. To prepare a comprehensive land and water resource plan, knowledge of the topography, hydrological characteristics and drainage pattern of the catchment is extremely important. The present study highlights the significance of Digital Elevation Model (DEM) and GIS for morphometric analysis of thirteen sub-watersheds of Mand catchment, Chhattisgarh which 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. Different parameters of various aspects including 6 linear, 12 areal and 7 relief parameters were found out in the environment of GIS. Standard methodology and formulae were applied as suggested by previous research workers in this study. Total area of the Mand catchment is 5332.07 sq.km in which WS7 has the maximum area of 943.68 sq.km and WS2 has the minimum area of 179.56 sq.km. The stream order of watershed ranges from first to fourth order showing dendritic to sub-dendritic drainage. High stream frequency values are observed in sub-watershed 6, 7, 9 and 11 which are accompanied with high relief and impermeable lithology. In sub-watershed 1, 2 and 4 the slope is relatively lesser and therefore yields less stream frequency value. In the study area, the values of mean bifurcation ratio vary from 2.25 to 6.44. Sub-watershed with high form factors (9, 10 and 12) experience higher peak flows of lesser duration, whereas elongated sub-watershed with low form factors (2, 6, 7 and 8) experiences lower peak flows of longer duration. Sub-watershed 7 (Re = 0.585) is most elongated among all therefore has the longest basin length i.e. 59.29 km. Sub-watersheds 2, 4 and 11 have low relief (R < 500 m). Sub-watersheds 2, 4 and 11 have low Rn (Ruggedness number) values whereas rest of the sub-watersheds showed high Rn value. The high Rn values represent the complex structures of a landscape which is highly prone to erosion. High relief ratio in sub-watersheds 3 and 8 demonstrates quick time of concentration, more stream flow velocity and was highly prone to erosion than other sub-watersheds. The present study shows that hydrological assessment based on SRTM DEM is more precise compared to other available techniques. This morphometric research analyse the individual sub-watershed characteristic and helps to explain the entire Mand catchment's hydrological behaviour.

Keywords: *Morphometric Analysis, Sub-watersheds, Remote Sensing, Geographic Information System, DEM*

Spectrum of Technological Options of Soil -Water Conservation Measures for Sustainable Agriculture

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Farming systems today have many implications than before because of the growing concerns about agricultural sustainability and environment. Soil and water, two integral factors and finite natural resources crucial for sustainable production systems are being deteriorated due to different natural and anthropogenic factors. The natural area of productive soils is under increasing pressure of intensification and competing uses for cropping, forestry, pasture and urbanization and increasingly threatened by anthropogenic activities such as erosion, humus and nutrient depletion, surface crusting, salinisation, degradation as well as contamination. Water is the most critical input for agriculture. Sixty per cent of our farms are rainfed. In India, agriculture sector consumes around 89% of total water use, as against 8% by domestic sector and 3% by industrial sector. Predictions are that the share of water for agriculture will reduce to 78% by 2025. Priority management of soil and water resources have therefore become imperative for reversing the trend of growing concerns for ensuring current and future global food security through conceptualization of various conservation programmes. Resource inventorization undertaken as part of survey activities throws light on the status of the natural resources, their limitations and ameliorative measures. The concept of soil conservation cannot be materialized without conserving and efficient use of water resources, therefore almost the methods that deal with soil conservation are principle methods to conserve water. Two broad major methods for management include biological or agronomic and vegetative measures and mechanical method. In biological method, growing cover crops, strip cropping, intercropping, crop-rotation, fallowing, biological nitrogen fixation, use of organic manures such as animal and green manures, regulating grazing, low-till farming or conservation tillage, agro-forestry, mulching etc. Mechanical measures constitute various engineering techniques and structures that reduce run-off velocity, impound water for a longer time and provide more absorption opportunity. The strategies for water conservation may be management oriented depending upon the field of water use, domestic, irrigation or industrial use. Contour bunding, contour tillage, terracing, outlet channel, basin lifting, diversion ditches, pan breaking and sub-soiling, water harvest through low earthen dams, farm ponds, percolation tanks rough surface, drip irrigation systems. The water conservation practices such as terraces and buffer strips reduce the intensity of flowing water by reducing the slope. The construction of water catchments and minimizing the soil slope reduces water runoff and thus decrease the erosion. Besides these measures, catchment approach, development of participatory methodologies for faster outscaling of successful conservation interventions, legislation for soil and water conservation under UNGC (Food and Agriculture Business Principles (FAB Principles) to create awareness through enlightened programs and draft principles to strengthen the existing government policies and policy frameworks. Even the Intergovernmental Technical Panel on Soils of the Global Soil Partnership recommends soil protection

and reclamation as well as sustainable land management projects; increase the area under sustainable soil management practices, enhance the restoration of degraded soils and promote "sustainable production intensification" through adapted biological resources, increasing soil fertility, water use efficiency, ensuring sustainable use of inputs and recycling of agricultural by-products.

Keywords: *Agriculture, Conservation, Resources, Soil & Water, Sustainable*

Soil and water conservation techniques

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Watershed management, particularly Soil and Water Conservation (SWC), supports sustainable livelihoods through reducing environmental degradation and increasing crop production (as it increases infiltration and reduces erosion as well as maintains soil fertility).

Techniques of soil and water conservation: - Afforestation: One of the best ways to conserve soil is to increase the area under forests, Checking Overgrazing: Grazing is very important, Constructing Dams: One of the scientific methods to check soil erosion. Changing Agricultural Practices One of the strategies in water conservation is rain water harvesting. Digging ponds, lakes, canals, expanding the water reservoir, and installing rain water catching ducts and filtration systems on homes are different methods of harvesting rain water. Soil and water conservation measures are predominantly applied for the following purposes: to control runoff and thus prevent loss of soil by soil erosion, to reduce soil compaction, to maintain or to improve soil fertility, to conserve or drain water and harvest (excess) water.

Water Productivity Enhancement in Upland Rice (*Oryza sativa* L.)

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Over the past decade we have witnessed a growing scarcity and competition for water around the world. Due to shrinking of water resources we cannot sustain even the existing level of rice production. In this context, it is necessary to enhance water productivity in rice production especially in upland rice cultivation which is now becoming popular. Upland rice cultivation is a resource conservation technology as it requires less irrigation water, low labour and is suitable for mechanization. Upland rice cultivation is a promising technology under water deficit situation. The water productivity and yield of upland rice can be enhanced by adopting different measures.

Upland rice varieties with short duration, modified root system, lodging resistance, early vigor and drought tolerance can be used. A proper water conveyance and distribution network ensures high water conveyance and application efficiencies in upland rice cultivation. The management practices including proper tillage, seed priming, timely sowing, proper irrigation scheduling, moisture conservation methods, suitable cropping systems, integrated nutrient management, integrated weed management, Biotechnological approaches, drought mitigation through Pink Pigmented Facultative Methylotrophs (PPFM) play an important role in enhancing water productivity and there by yield of upland rice.

Keywords: *Upland rice, varieties, management practices*

Performance of high yielding variety of sesame grow on raised bed in cluster front line demonstration under Bundelkhand condition

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Sesame (*Sesame indicum*) commonly known as *Til* is an ancient oilseed crop. Sesame oil is often considered the "queen" of vegetable oils. India ranks first, both in the area and production of sesame in the world. Sesame is grown in India in *Kharif*, semi-arid, *rabi* and summer season or more than one season in some states. The crop has not only earned foreign exchange through export but also augmented the oil production in the country. In Bundelkhand region of Utttar Pradesh, sesame grows well in the undulated topography either as sole crop or intercropped with millet or sorghum. Within the Bundelkhand Banda is one of sesame producing area. Since sesame is widely utilized as oil crop by the people in world, its market price is much higher than all other crops. Despite the aforementioned importance of the crop, its current production is constrained by various problems in the District and water lodging is most important. Thus development of location specific agronomic practices like sowing method, optimum plant population and inter- row spacing are necessary to enhance the productivity of sesame in the region. The broadcasting method of sowing is followed by most of the farmers and some farmers are also doing the line sowing of sesame. The uneven pattern of rainfall often caused the water lodged condition and crops suffer. Considering this particular constrain Clusters Front Line Demonstration (CFLD) on sesame crop was conducted on an area of 20 ha with active participation of 50 farmers with improved technologies composed of RT 351 variety and raised bed sowing method for enhancing productivity of sesame. Severe stress to the plant under waterlogged condition is significantly reduced by this system over the conventional flat sowing system. Improvements in soil aeration, extension of root system, and increases in plant tolerance to root rots have been known as benefits of sowing sesame crops on raised beds during rainy seasons.

The results revealed that improved demonstrated technology of sesame sowing recorded maximum mean yield 2.49q/ha with an increase in 27.69per cent over farmers practice (1.95q/ha). The extension gap can be bridged by popularizing package of practices of sesame composed high yielding variety RT 351 and raised bed sowing method. Improved technologies gave higher net return of Rs. 8895/ha with benefit cost ratio of 2.85, as compared to net return from farmers practice Rs. 6225/ha with benefit cost ratio of 2.38. It was concluded that the Raised Bed planting Technology for crop production in uneven topography is suitable for sesame crop to mitigate water lodging, draught and, erratic rainfall under Bundelkhand conditions. This technique reduced soil erosion and allows crop plant to grow healthy and face minimum water logging stress as plants are grown on ridges and furrows act as drainage lines for excess water. This method is also save water and increase quality and yield. The observations indicate that the raised bed technology is better option for sesame cultivation even in the undulated topography of Bundelkhand.

GIS based spatial distribution and evaluation of water quality for irrigation purpose in Haridwar district

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Water is the main resource of life on Earth. Groundwater is the major factor for fulfilling the agricultural and domestic demand of Haridwar district. Haridwar district lies in the south- western part of Uttarakhand state. The increasing demand for good quality of water for drinking and other daily activities across all sectors have put a massive pressure on groundwater, resulting in continuous depletion and quality deterioration in Indo- Gangetic plains of Uttarakhand. The heavy industrialization in Haridwar district of Uttarakhand has resulted in generating considerable toxic effluents contaminating the groundwater of the district. To counter this issue, a study based on physico-chemical characteristic of groundwater for the area was done to determine its suitability for irrigation purpose using water quality index method and the thematic maps of different physico-chemical parameters were generated using the inverse distance weighted interpolation method in GIS software. The result showed that the groundwater from nearly 80% locations was found safe for irrigation use whereas, at the rest 20% locations the groundwater could be used for irrigation by adopting salinity control measures, proper drainage system and by planting salt tolerating crop. The quality of groundwater from shallow aquifer was categorised in the moderate to high restriction category which indicated that for irrigation it must be used on high permeability soils along with adopting measures for leaching.

Keywords: *Groundwater, Spatial distribution map, Thematic map, Irrigation water quality*

Role of GIS and RS in Natural Resource Management

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The economic, social and cultural viability of any nation is mainly determined by the land and water resources that it has. Agricultural production systems are highly vulnerable to variations in climate, soil and topography of different regions. RS, GPS and GIS can be of great use for their assessment and management. These technologies have manifold applications in agriculture including crop discrimination, crop growth monitoring / stress detection, crop inventory, soil moisture estimation, computation of crop evapo-transpiration, site-specific management / precision agriculture, crop acreage estimation and yield prediction. Timely and reliable information on crop acreage, growth condition and yield estimation can be highly beneficial to the producers, managers and policy planners for taking tactical decisions regarding food security, import/export and economic impact. These technologies can be used to develop a variety of maps. Examples are land cover maps, vegetation maps, soil maps, geology maps. However, before these maps are developed, there are a variety of data that need to be collected and analysed. Data can be collected using either ground photographs, aerial photographs or satellite photographs of the area. The data that is collected on the ground is geo- referenced with the help of a GPS to ensure that its corresponding location can be accurately identified in the images that were collected earlier. GIS and RS are crucial elements of forest management as well. This technology helps understand the land cover, availability, area, and human encroachment of protected forest areas. This information plays a very important role in forest management and decision making. It is also used in watershed management, which is crucial for understanding the water streams and integration of water resources available, in studying and preventing desertification of areas, and even in biodiversity management. Pressure on resources is increasing by the day, with GIS, there is hope that this pressure can be reduced- and if not reduced, at least it can be studied to find areas where it is beyond the threshold. GPS can be used to determine the soil types and nutrient availability in soils. GIS data can also used to determine the land use practices within a given area and vegetation constitution and the impact that they have on the environment. Consequently, slope information of a region can also be determined with the use of GIS data. GPS can also be used in the management of flora and fauna within protected areas. Use of GPS technology can be applied to monitor the movement of endangered species as well as newly introduced species to determine their progress as well as protecting them form poachers. Thus, with the understanding of these factors, sound decisions can be arrived at that will ensure the sustainable use of natural resources to meet the needs of the present generation as well as future generations.

Keywords: *Climate change, Crop acreage, Crop growth, Remote sensing*

Options for improving crop water productivity in hot arid region

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Given the limitations to increase the supply of water for agriculture due to intensifying competition from other sectors (industry, domestic) along with uncertainties associated with climate change, improving crop water productivity (CWP) is an urgent need in hot arid regions. Many options like deficit irrigation, mulching, tillage, soil organic amendments, cropping system diversification, nutrient application have been identified for enhancing CWP in hot arid region. The substitution of higher water consumption crop like groundnut and wheat with low water requiring crops like cluster bean, mung bean, Indian mustard and blond psyllium have demonstrated to save irrigation water and enhance CWP. Cluster bean – blond psyllium and cluster bean – Indian mustard had shown to save 150-200 mm irrigation water and better economic return than conventional cluster bean – wheat cropping systems. It has been demonstrated that profitability and CWP of crop production can be improved, compared with groundnut–wheat cropping, by substituting groundnut by mung bean. Application of 20 to 30% deficit irrigation has shown to increase WP with substantial saving of irrigation water for wheat, ground nut, cotton and Indian mustard. It has been demonstrated that suitable soil management, i.e. tillage and FYM is effective for enhancing crop yield without much affecting water consumption by crops, thereby enhance CWP. Deep tillage and application of FYM@ 5 to 10 Mg ha^{-1} are found to increase CWP. Even though, there are many options for enhancing CWP, the most appropriate option(s) will vary from site to site, depending on pedo-climatic conditions of the site, and social and economic conditions of the farmers/stakeholders. Therefore, there is need to select and implement the techniques for improving CWP according to biophysical and socioeconomic factors of the region. A single approach would not be capable of improving CWP with acceptable or higher crop yields with limited or even reduced water supply. Combining biological water saving measures with engineering solutions, agronomic measures and manipulation soil environment in an integrated manner is the best suitable strategy for improving WP. Furthermore, the trade-offs between CWP and yield and CWP and nutrient-use efficiency need to be considered for designing and implementation of techniques for improving WP. The adoption of techniques to improve CWP requires an enabling policies and institutional environment that aligns the incentives of producers, resource managers and society, and provides a mechanism for dealing with trade-offs.

Keywords: *Arid ecosystem, Crop diversification, Deficit irrigation, Soil management, Water productivity*

Applications of Hydrological Models for Improved Irrigation Management in Changing Climatic Scenario

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Global food security threatened by climate change is one of the most important challenges in the 21st century to supply sufficient food for the increasing population while sustaining the already stressed environment. Climate change has already caused significant impacts on water resources, food security, hydropower, human health in the whole world. Over the past decade, many countries around the world have witnessed serious water shortages particularly in India. The highest consumption of the available water is attributed to agriculture practices (81%) in India. The dependence on water for food production has become a critical constraint to enhance food productivity. Increasing scarcity and growing competition for available water makes a sense of judicious use of water in agricultural sector. Intensified irrigation may increase the rate of environmental degradation, water availability and its saving can increase crop yield. Understanding the current situation of the country, there is a need of irrigation scheduling and efficient use of water in an appropriate manner. Primitive approaches of water utilization are limited to some factors *viz.*, time consuming, lack of correlation with the changing climatic conditions, unavailability of predictions etc. At present, there are many types of crop simulation models available in which hydrological models that is CROPWAT, AQUACROP and INFOCROP are useful for judicious use of water in agricultural sector. Hydrological models increasingly are being used as an alternative for rapid assessment of water-limited crop yield over a wide range of environmental and management conditions. The Hydrological models play an important role in resource management tactics in the agricultural field, and have been used to understand, observe, and utilize the water resources efficiently in the changing climatic scenario of different crop systems. The Hydrological models are specially designed for water management planning in irrigation schemes. It is used for the planning of irrigation scheduling for rain-fed or irrigated crops under different water supply conditions and in the context of irrigation deficits. Importantly, according to researches, using the hydrological models has resulted in need based and real time application of available water to the field. Hydrological models can increase the efficiency of water use by decreasing the excessive losses at the farmers' field and ultimately to more area can be irrigated from the limited irrigation availability. Hydrological models are also helpful to determine the crop yield, crop water use, and the relationships between the yield and water use under different crop management practices.

Keywords: *Climate Change, Hydrological model, Crop water requirement, Irrigation*

Solar Powered Automated Drip Irrigation System Along With Wireless Sensor Network Technology: A Solution for Soil Moisture Stress- A Review

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After 25-30 years there will be a serious problem for food. In order to meet this food problem, there is a need for producing more agriculture yields using the available limited resources and by adopting the best techniques. 70% of farmers depend on the agriculture and farmers are suffering from the lack of rains and scarcity of water today. In India most of the irrigation systems are operated manually. In order to produce "more crop per drop", A site-specific wireless sensor-based irrigation control system is a potential solution to optimize yields and maximize water use efficiency. Soil moisture sensor can be used at multiple places in the field for getting the better accuracy. Increase in agricultural production depends to a large extent on the availability of water and power. Even if the farm land has a water-pump, most of the time it is not used due to non-availability of power in the remote areas. If the solar power is harnessed, an agricultural pump can run without depending on grid power. Solar powered automated drip irrigation system (SPADIS) is the solution for these problem by adopting wireless sensor network technology (WSNT) by integrating Solar Photovoltaic System (SPV), Soil Moisture Sensor, Mobile Bluetooth, Water Tank, Pump etc. Sensors can be used for remote monitoring and controlling of the devices via short message service (SMS) and global system for mobile (GSM). This system has ability to apply site-specific irrigation management to match spatially and temporally variable conditions. WSNT employed in this work contributes not only to save energy, water, fertilizers but also ensure uniform watering at right time without manual intervention leading to enhance the quality and quantity of agricultural yields. Global System for Mobile (GSM) technology can be used for communication purpose to inform farmers about the exact field condition and also help the farmers to have full remote access on their field cultivation activities which includes watering the crops at right time by operating the pump remotely. Temporal monitoring of soil moisture at different growth stages of crop could prevent water stress and improve the crop yield. Once, the battery is charged the pump can be run without the solar power or external supply; only with the help of battery and inverter. The advantages of using wireless sensor is to reduce wiring and piping costs, easier installation and maintenance especially in large areas.

Keywords: *Solar powered automated drip irrigation system (SPADIS), Global System for Mobile (GSM) and wireless sensor network technology (WSNT)*

Evaluation of irrigation strategies using Water Evaluation and Planning Model (WEAP)

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Changing climate patterns is likely to affect the availability of water resources for agriculture in the Bundelkhand region of India. The demand and supply of water for irrigation will be influenced not only by the changes in climate and subsequent changes in hydrology but also by the increase in the competition for water in the future between the agricultural and non-agricultural users. Therefore, planning irrigation water resources for agriculture are very important in this water-scarce area. This study evaluates various irrigation scenarios in Ur river Watershed of Tikamgarh District, Madhya Pradesh using a calibrated WEAP model. The future climatic predictions of the GFDL-ESM2M GCM model for RCP 4.5 were considered for creating various irrigation scenarios. WEAP model calculates the water balance for every node and link in the system at each time step. The crop library for all the *kharif* and *rabi* crops was developed for input to WEAP. For modeling purposes, the Ur River watershed was divided into eight sub-watersheds according to drainage network, topography, and soil types. We considered three different irrigation management scenarios (from the year 2012-13 to 2029-30) for these eight sub-watersheds, viz., Irrigation stress for 10 days during the Initial and Development stage, Irrigation stress for 10 days during late season stage and Full supply of water to demand from water sources. The results showed that the stress condition at different stages of the crop, affect its yield. The *kharif* crops are more water sensitive; therefore, the effect of water stress on final yield was more profound. The findings of the study are useful for formulating a water management plan for the study area.

Keywords: *Bundelkhand, Irrigation, Kharif, WEAP, WEAP-MABIA*

Dynamics of Drip Irrigation to Enhance Crop Water Productivity

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Worldwide, water use efficiency in irrigation tends to be low, with national averages in the range of 25 –50% (Tiwari and Dinar, 2001). Drip Irrigation has defined as the application of water through point or line sources on or below the soil surface at a small operating pressure of 20 to 200 kPa (0.2 to 2.0 kg/cm^2) and at a low discharge rate of 1 to 15 lph per emitter, resulting in partial wetting of the soil surface. A study on response of summer groundnut to plant density and nutrient doses under check basin irrigation and drip-fertigation for three consecutive summer seasons in the semi-arid Saurashtra region of India. The higher plant density of 4,99,999 plants/ha gave significantly higher pod under check basin irrigation while, no significant improvement in pod yield was obtained due to increased plant density under drip fertigation. Application of 100 percent of nutrient doses i.e., 25-50-30 NPK kg/ha gave significantly higher pod over 75 percent nutrient doses under check basin irrigation. However, under drip fertigation application of 75 percent nutrient doses gave yield levels and net returns, which were at par with that obtained with application of 100 and 125 percent of nutrient doses. Further, mean results indicated that drip fertigation gave 12.1 percent and 4.3 percent higher pod yield and net returns, respectively. Sensor-based automated drip irrigation (DI) which has considered as a smart and real time water application technique might increase the water savings and enhance yield of banana. The highest vegetative growth of plants (plant height, canopy diameter, stem girth) were observe with manually operated DI. However, sensor-based DI produced 15 percent higher fruit yield with 20 percent water saving, resulting in 40 percent higher water productivity (yield per unit quantity of water) compared with manually operated DI.

Keywords: *Drip Irrigation, Water Productivity, Sensor based Drip Irrigation, Fertigation*

Application of Modern Tools in Agricultural Water Management

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Automation is the technology by which performance of complex operation with minimal human assistance. The major challenges in agriculture in coming decades are availability of cheap labour, to enhance more crop per drop i.e., water productivity and input use efficiency. Since, water is one of the challenging inputs for the future agriculture in paradigm of climate change hence; automation in agriculture water management will be one of the key solution. This paper is aiming to do a systematic review related to automation application in agriculture water management along with the advantages and future challenges. The new scenario of decreasing water, drying up of rivers and tanks, unpredictable environment, present an urgent need of proper utilization of water. In this technique, various types of sensors (temperature, humidity, and moisture) placed in different locations of the field and monitor these sensors. Once the moisture level is reached 50% or at allowed depletion level of the available water, the sensor will automatically communicate this to the users mobile and can enable the motor operation. However, use of technology in the field of agriculture plays an important role in increasing the production as well as in reducing the man power. This idea proposes a novel methodology for smart farming by linking a smart sensing system and smart irrigation system through wireless communication technology. By using automated irrigation technology can help the development of agricultural automation for small and marginal farmers to achieve the advantages of low cost, high efficiency and high precision. Challenges related to the above technology includes the initial cost, lack of knowledge among the farmers for the operation of this system and technical related issues related to the system.

Keywords: *Automation, Irrigation, Water Management, Smart Irrigation*

Foliar application of Sampoorna KAU Multi mix to address micronutrient stress

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Multi-nutrient mixtures were developed for foliar application in different crops to address the micronutrient deficiencies observed commonly in Kerala Fields. Experiments were conducted to evaluate their suitability for correcting the nutrient deficiencies and improving yield. Multi-nutrient mixtures were developed at RARS Pattambi using nutrient carriers for foliar application in rice, banana and vegetable crops. Initially, compatible chemicals were identified by considering the mixing compatibility, solubility and storage properties in a number of permutations and combinations of the component chemical materials. With the compatible nine compound base formula, experiments were conducted to formulate crop specific nutrient mixtures. The nutrient uptake by the crops, status of available nutrients in Kerala soils and the optimum, sufficiency and toxic ranges of the nutrients in the particular crop were considered while fixing the proportion of the compatible chemicals in the mixture. The multi-nutrient mixtures contain potassium, magnesium, sulphur, zinc, copper, boron and molybdenum. The experimental results indicate that foliar application of the mixtures could improve crop productivity. As foliar application decreases the nutrient load in to the environment, multi nutrient mixtures offer a sustainable option for management of nutrient deficiencies. The seed priming and foliar application of the Sampoorna KAU Multimix in rice nursery resulted in better establishment of seedlings and crop yield.

Keywords: *foliar application, micronutrients, multi-nutrient*

MOOCs on Water Harvesting Conservation and Utilization

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Water plays an important role in all aspects of socio-economic development as well as maintenance of healthy ecosystems. The rapid urbanization and change in lifestyle have led to severe crisis of useable water in developing countries like India. The per capita water availability has shown an unswerving declining trend over the years and it was 1545 m ^{3}/year in 2011, may further reduce to 1486 m^3/year in 2021 and it is estimated to decline further upto 1140 m^3/year in the year 2050. There is a substantial gap between the demand-supply since the requirement for water in various sectors is continuously increasing and in turn the resources are rapidly decreasing. According to a 2018 NITI Aayog Report, almost two lakh people die every year due to inadequate access to safe, good quality potable water and presently about 60 crore citizens of the country face high to extreme water stress conditions. There is an urgent need for adopting water harvesting and conservation measures like rainwater harvesting, preventing pollution, management of surface and ground water resources etc. It is envisaged that active participation of local people plays a pivotal role in management of this important natural resource. For achieving this, there is an urgent need for creating awareness and sensitizing the public as well as all the stakeholders in the society. The SWAYAM is an MHRD initiative for offering Massive Open Online Course (MOOC) through an online platform which allows the users to participate with no or low cost, without spatial or temporal limitations. It is proposed to offer a MOOC on Water Harvesting, Conservation and Utilization for the benefit of large sections of the society and to create human resource in this sector. The present paper reflects on the need and scope of MOOC course on Water Harvesting, Conservation and Utilization.

Keywords: *MOOCs, Water, Harvesting, Conservation, Management*

Happy seeder technology for residue management in rice-wheat rotation

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Rice-wheat rotation of North-West India has contributed significantly to country's "food basket" and will remain very important for future food security, farmers' income and livelihoods of rural population. However, there are several issues of sustainability of this system. About 70-75% of the total rice straw produced is burned in the fields in a short window of 15-20 days which has serious environmental, human and animal health implications in addition to a substantial loss of plant nutrients (especially N and S) and organic carbon. Punjab Agricultural University, Ludhiana has developed various site- and situation-specific straw management techniques to manage rice straw left in the field after combine harvesting. But after the launch of centrally sponsored In-situ Crop Residue Management project in 2018, implementation of a sustainable and scalable in-situ crop residue management practices in Punjab has been increased to support farmers for machinery, capacity development, knowledge sharing and awareness creation. It can effectively be managed within the same field by sowing wheat with Happy Seeder after harvesting of rice with combine harvester fitted with PAU-SMS. Rice straw can be incorporated with mould board plough after chopping with straw chopper or mulcher or it can be collected and removed either mechanically or manually from the harvested rice fields. *Phalaris minor Retz.* is the most pernicious and competitive weed in wheat in Punjab, causing significant yield losses in rice-wheat cropping system. Covering or mulching the soil surface using crop residues can reduce weed problems by preventing weed seed germination or by suppressing the growth of emerging weed seedlings. Extensive field trials were conducted in district S.A.S Nagar (Mohali) Punjab during Rabi 2018-19 to analyze the performance of different rice straw management technologies at farmers' fields in 400 acres. Farmers following conventional straw burning was also taken for comparison. Our results showed that happy seeder-based in-situ management systems emerged as the most profitable and scalable residue management practice as they are, on average, 10-20% more profitable than burning. Average increase in wheat yield was around 3-4 % in these demonstration plots as compared to non crop residue management (burning) plots. The biggest advantage of using these technologies was decrease in cost of field preparation to the extent of Rs 5000/ha and saving of spray cost on agro chemicals (insecticides) and herbicides, which has resulted in higher profit and increased net return. This mission also created the awareness, capacity building and created the business opportunities for the farmers, custom-hiring centers and co-operatives. The results of this study not only have scientific relevance but have wider practical applicability and scalability for the society as well.

Keywords: *happy seeder, residue management*

Studies on effects of crop geometry and varieties on yield and yield attributes of mustard under Poplar in Terai of UP

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A field experiment was conducted at farmer's field in Distt. Pilibhit of Western Terai and Bhabar region of U.P., India, during rabi season of 2017-2018 and 2018-2019, to find out suitable variety and optimum spacing for different Mustard varieties, as pure and under Poplar trees. Three varieties of Mustard, *viz.* Goldi (V1), Ullahas (V2) and Pant pili sarson-1(V3) were taken as treatments in the main plot, wheras, four spacings, 40cm x 30cm(S1), 45cm x 20cm(S2), 30cm x 15cm(S3) and 20cm x 10cm(S4), were imposed as subplot treatment, in pure field as well as under trees. The experiment was conducted in split plot design with 3-replications and repeated in rabi seasons for two consecutive years (2017-2018 and 2018-2019).

The results of the experiment revealed that the maximum seed yield was recorded in Pant pili Sarson-1 (1648.0kg/ha and 2052.0kg/ha, respectively in 1st and 2nd year) followed by Goldi and Ullahas. And, seed yield of Pant pili sarson-1 under Poplar trees was also recorded highest in both the years under 2 and 3years plantation (1542.0kg/ha and 1422.0kg/ha, respectively).

The same pattern was also seen for stover yield(kg/ha) in pure as well as in intercropped fields.

Regarding, plant geometry significantly higher yield was seen in 40cm x 30cm (2241.0kg/ha and 2836.0kg/ha, respectively in 1st and 2nd year) in Pant pili Sarson-1. The same pattern was observed in Goldi, followed by Ullahas. Similar results were also noticed in Mustard, grown with trees.

Crop geometry (40cm x 30cm), observed the best in respect of number of primary branches/plant and seeds/siliqua, and it was also reflected on seed yield and Stover yield (kg/ha).

The Pant pili Sarson-1, of Mustard is highly suitable and recommended in Terai region of U.P., due to its higher yield. So, wider spacing is suitable for Pant pili sarson-1, because of their bigger canopy.

Keywords: *Yield, Yield attributes, Crop geometry, Pant pili Sarson-1, Mustard, Agroforestry, Poplar*

Improved Technological Intervention for Drudgery Reduction of Farm Women

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India being an agricultural country where 70% of Indian population depends on this occupation for livelihood. Due to lack of access to improved technologies in the field of agriculture, it is quite often known a drudgery prone occupation. The era of Green revolution is one of the foremost periods in India where adoption of modern methods and technology such as HYV seeds, tractor, irrigation facilities, pesticides, and fertilizers was concentrated. Technology intervention was mainly concentrated to achieve food security and economic development. Farm women and men both strive to carry out all agricultural operations often through traditional methods, which in turn causes heavy workloads and results in stress and poor health condition of farmers. Recent decades have made tremendous improvement in farm efficiency by mechanizing the farm operations. Introduction of many simple cost-effective drudgery reducing technologies have saved millions of farmers from heavy works and stress. When considered Farm women in particular who constitute almost 50 percent of the agricultural work force in India. They are sometimes also known as invisible farmers where their heavy work participation in farm goes unnoticed. So there is a need for such drudgery reducing tools and implements in developing countries like India which would greatly enhance the productivity of farm women workers. When comes to adoption of improved technologies main constraints are small and fragmented holdings and low socio-economic conditions of the farmers. Therefore, in this regard many Efforts have been undertaken in ICAR Research Institutes and State Agricultural Universities to ergonomically design the tools for gender friendly operations. Directorate of Research on Women in Agriculture also have been consolidated to develop such gender friendly technologies. Women friendly tools and implements developed by Central Institute of Agricultural Engineering (CIAE), Bhopal drew the attention of US President Barack Obama and received appreciation for the exclusiveness and novelty. These include equipment for different categories of operations such as land preparation, seed treatment, intercultural and post-harvest in agriculture and allied sectors and household's technologies. This paper showcases the improved drudgery reducing technologies for encouraging farm women. Development of research in this line would help farm women for drudgery free and enthusiasm work. More funds need to be invested in the public sector so that high-quality scientists will work on agricultural research that is available to all. Research and development of technology is not just enough for the adoption of technologies, always developments in research need to be accompanied by training for farm women on new developments and how they should adapt. Consideration should be given to establishing regional centers where information on best practices/technologies or success stories can be accessed by farmer organizations and others. Thus, in conclusion, in this rapid changing world, we need to concentrate on what is needed to stay sustainable. Introducing technology and improvising the technology can fulfil that path and in turn lead to real empowering the women.

Keywords: *Women, Drudgery, Drudgery reducing technologies*

Using Remote Sensing and GIS for managing soil and water resources towards food and livelihood security

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Natural resources are considered wealth of a country. Managing them judiciously contributes towards the overall growth of a country. India is blessed with a varied form of natural resources. Since the last century it has started managing its resources. After independence the biggest challenge facing the country was to feed its ever growing population. The foresightedness of policy makers and planners helped India to overcome this problem. The country became self sufficient in food grain. However to design, develop and implement policies over a large country the need of technologies over space and time was developed. With the climate change phenomena becoming more prominent and the frequency of unpredictable rainfall intensities and duration on the rise, the country realized another challenge coming forth. The challenge of food and livelihood security. Here remote sensing and GIS came to our rescue. Since 1966 the country has several satellites, trained human resource, developed technologies and has several success stories to its credit. The role of remote sensing has entered all the domains including natural resources. The Indian remote sensing story is an ongoing successful venture of the Government of India. This paper discusses the use of remotely sensed technology in eradicating poverty by providing better solutions for land and water resources and its contribution towards food and livelihood security in the country.

Impact of land use capability classes and present land use on soil properties and erodibility behaviour of Sheetalpur watershed of Hamirpur district of Bundelkhand region of Uttar Pradesh

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This case study was carried out in Sheetalpur watershed in district Hamirpur of Bundelkhand region of Uttar Pradesh (India) under Operational Research Project for Resource Development to assess the erodibility for strategic planning to obtain maximum possible production on sustained basis. Soil erodibility characterization in different soil series of Sheetalpur watershed in district Hamirpur (Uttar Pradesh) representing typical black soil were richer in water stable aggregates and less erodible as compared to red soil. The results of this investigation represent that erodibility among the project area increases from land use capability class II to VII. Ravines lands are most erodible followed by cultivated lands while orchards and woodlots are least erodible. On the basis of water stable aggregates, dispersion and erosion ratio as principal indices of erodibility, soils under various land use capability classes may be arranged in the order of Class VII> Class VI> Class IV >Class III > Class II. The erodibility of soils under different present land use was found in the order: Deep ravines>Fallow land> Range lands>Cultivated land > Orchard and woodlots land. Erosion ratio was significant and negatively correlated with clay (r = -0.856**), silt+clay (r = -0.445*), moisture equivalent (r = -0.684**), water holding capacity (r = -0.703**), organic carbon (r = -0.809**) and clay/moisture equivalent ratio (r = -0.714**) while positively correlated with easily dispersible silt+clay (r = 0.792**), dispersion ratio (r = 0.946**) and erosion index (r = 0.970**). A significant and positive correlation was recorded for water stable aggregates with clay (r = 0.823**), silt+clay (r = 0.803**) and moisture equivalent ratio (r = 0.807**) and a negative correlation with easily dispersible silt+clay (r = -0.561*), dispersion ratio (r = -0.807), erosion index (r = -0.739) and erosion ratio (r = -0.653). Among various land use capability classes, soil erodibility decreased substantially with increasing clay content but increased with increasing slope percentage, advancing capability class and fallow land use. Soils of Sheetalpur watershed are erosive in nature and require warrant and prompt attention for implementing intensive soil conservation measures in the entire watershed in order to subside the havoc of soil erosion within safe limits because adopted soil conservation measure are variably effective to control the erosion.

Keywords: *Erodibility, Bundelkhand soils, land use capability classes.*

Development and Performance Assessment of Soil Moisture Sensors in Sandy loam and Laterite Soil

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Soil moisture sensors (SMS) are used to determinate soil moisture content (SMC) for automatic irrigation scheduling, but the cost of sensors available in market is very expensive. The objective of present study was to developed low-cost SMS based on electrical conductivity and calibration of the sensors with sandy loam and laterite soils. Three SMS were developed based on electrical conductivity principal. Developed sensors were simple, precise, sensitive, lightweight and cost-effective. Performance of SMS were evaluated and calibration curve between the SMC and soil electrical conductivity (SEC) were also developed under laboratory condition. Reciprocal model was found best fit modal and mathematical model was developed for each sensor. It was observed that the calibration of three sensors give the similar calibration equation having a quite low standard error and high regression coefficient and ensuring good performances after laboratory calibration. The value of regression coefficient was 0.9999707, 0.9999304 and 0.9999747 and Standard Error 0.0233151, 0.0338273 and 0.0202821 for S1, S2 and S3 respectively for sandy loam soil. In the case of laterite soil. regression coefficient for S1, S2 and S3 0.9999940, 0.9999988 and 0.9996347 respectively and standard error 0.003027, 0.0030025 and 0.0766141 for S1, S2 and S3 respectively. Performance of sensors was found satisfactory in both types of soil. Calibration curve was not repeatable, when the sensors are used in different soils. Hence, it is important to calibrate the sensor in different types of major soils, where sensors were installed used.

Keywords: *Soil Moisture Content, Sensor, Electrical Conductivity and Reciprocal Model.*

Open Dug well for increasing cropped area in hard rock area of Odisha

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Open dug well is the most common means of irrigation system in all most all parts of India. It is being used for both domestic and agriculture purposes. In hard rock area, groundwater table depth is quite below the ground surface; hence exploitation of groundwater through deep bore wells is very costly and uncertain. In these areas open dug wells are being used to tap water from first aquifer by using a pumps or buckets depending on its depth. Dug well act as recharge structures in hard rock areas provided it is constructed at appropriate location. In this paper a study was conducted at Bargharia nala micro watershed located in Daspalla block of Nayagarh district of Odisha which falls in western central plateau region mainly dominated by hard rock aquifer. Total geographical area of the watershed is 637.45 ha. The use of surface water is limited to rainfed crops and groundwater use is limited to drinking water purpose only. The area experiences a sub humid climate and receives an average annual rainfall of 1427mm (1994–2017) with 82 numbers of rainy days per year. There is presence of rain water harvesting structures and dug wells within the watershed, but water was not sufficient to support irrigation system during *rabi* and summer season. Interventions were carried out to identify locations for construction of recharge structures within the watershed. Then along with soil conservation and watershed departments recharge structures were created in appropriate locations. Its impact was studied through increase in cropped area, water availability in surrounding dug wells located within the area of influence of structures. Study of dug well hydraulics during post monsoon and summer season revealed that drawdown of 50cm was recuperated in 12 hours of time period that means recuperation rate was enhanced from pre to post intervention period. Hence the dug well command area enhanced from 0.2 ha to 1.5 ha in this location. Vegetable cropped area (brinjal, cabbage, cauliflower, tomato) with 5-6 cm irrigation water could enhance the yield and farm income substantially. Hence dug wells helped to increase the total command upto 10-12 ha area in Srirampur village located in hard rock areas of Odisha.

Keywords: *dug well, Odisha, rainfall*

Impact of resource conservation techniques on runoff and sediment yield in lower Shivaliks of Jammu

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In India land degradation is a common problem in the lower Shivaliks of Jammu, extending from district Kathua in the southeast to Rajouri in the northwest. It is a dry semi-hilly belt, locally known as kandi. Increased human and cattle population pressure and decreased the size of land holdings in the area have resulted in the indiscriminate felling of trees, removal of bushes and grazing and browsing. It has led to unabated soil loss and loss degradation**.** So an experiment was laid out to compare the impact of resource conservation techniques on the runoff and sediment yield in two different catchment areas (one with sandy loam texture and other with clay loam texture) in lower *Shivaliks* of Jammu. The slope of the catchment areas varies from 3-6%. From the studies it was concluded that besides controlling runoff and sediment yield, the resource conservation techniques were also effective in improving the various physico- chemical properties of the soils. The highest value of runoff (55.10 m ^{3} ha $^{-1}$ yr $^{-1}$ in sandy loam and 53.00 m ^{3} ha $^{-1}$ yr $^{-1}$ in clay loam) and sediment yield (9.17 t ha^{-1} yr^{-1} in sandy loam and 7.36 t ha^{-1} yr^{-1}) in both the catchments were recorded in overgrazing prevention and lowest in cover crop. The value of pH in sandy loam (7.84) and clay loam (7.73) was highest in cover crop and lowest (7.33 in sandy loam and 6.64 in clay loam) in overgrazing prevention. The organic carbon content was highest in cover crop in both sandy and clay loam soils *i.e.* (8.14g kg^{-1}) and (8.25g kg^{-1}) and lowest in overgrazing prevention (2.11g kg^{-1}) and (2.37 g kg^{-1}), respectively. The highest value of available nitrogen, phosphorus and potassium were recorded in cover crop *i.e.* (426.22 kg ha^{-1} and 440.10 kg ha^{-1}), (28.52 kg ha^{-1} and 30.29 kg ha^{-1}) & (292.04 kg ha^{-1}and 309.70 kg ha^{-1}) in both sandy loam and clay loam respectively. The quantification of nutrient losses in both the soils revealed that the losses of total nitrogen (24- 26 kg ha^{-1} yr^{-1} in sandy loam & 8.2–14.0 kg ha^{-1} yr^{-1}in clay loam), phosphorus (29.0 – 30.0 kg ha^{-1} yr^{-1} in sandy loam & 16.0 – 24.0 kg ha^{-1} yr^{-1} in clay loam) & potassium (23.0 – 29.0 kg ha^{-1} yr^{-1} in sandy loam &8.0 – 10.42 kg ha^{-1} yr^{-1} in lay loam) were maximum in overgrazing prevention and minimum in cover crop. Various physico-chemical properties of the soil influenced the runoff & sediment losses. In sandy loam (7.3 Mg ha^{-1} yr^{-1}) and clay loam (7.0 Mg ha^{-1} yr^{-1}) cover crop has the highest value of soil loss tolerance limit. The water yield (mm) was highest in overgrazing prevention *i.e.* (370 mm-Ist year and 292 mm-IInd year in sandy loam) and (350 mm-Ist year and 285 mm- IInd year in clay loam) and lowest in cover crop (140 mm-Ist year and 92mm-IInd & 120 mm--Ist year and 64 mm-IInd in sandy and clayey soils, respectively). From the above study we can conclude that resource conservation techniques are very effective in controlling soil and water losses due to runoff and sediment yield and therefore are required here to adopt these practices in sub montane *Shivalik*.

Keywords: *Resource conservation techniques, runoff, sediment yield*

Potential of different media based and floricultural crops grown vertical subsurface flow-constructed wetland system for water stress mitigation

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Water scarcity is one of the major challenges facing the whole world including India. Climate change, environmental degradation and pollution are affecting the available water resources both in terms of quality as well as quantity. Since agriculture is the largest consumer of water and so, world research has focused on the various adaptation and mitigation strategies *viz.* developing genetically improved drought-resistant crop varieties, developing techniques for less water consuming agricultural practices, decreasing water losses, increasing water storage as well as research on additional water sources. Now a day's, waste water agriculture became a worldwide adopted phenomenon. In absence of freshwater resources, many farmers in peri-urban areas already using wastewater for growing crops, vegetables, fishery etc. Therefore, wastewater seemed an additional water resource and research has started for developing techniques for low cost, less energy-intensive and sustainable treatment technologies. In this line, a research was conducted at ICAR-National Institute of Abiotic Stress Management, Baramati and used different growing media *viz.* gravel, coco peat, charcoal, rice hull along with media less control based vertical subsurface flow constructed wetland system (VSSF-CWs) for treating septic tank wastewater. In these media-based systems different flowering crops *viz.* chrysanthemum, marigold, sweet basil, aster, tuberose and gladiolas were grown with the aim to integrate water treatment systems with floriculture industry and develop a business model for peri-urban farmers. Various physico-chemical-microbial water quality parameters of both untreated and treated water were tested like Biochemical Oxygen Demand (BOD), pH, electrical conductivity, carbonate, bicarbonate, chloride, Ca+Mg, fluoride, nitrate, phosphate, sulphate, sodium, potassium, heavy metals, total coliform, faecal coliform, *Escherichia coli* etc. These treated waters are using further in aquaponics system grown with spinach and Pangasius fish after passing through a 25-watt UV sterilization unit. Among different flowering crops marigold grown on gravel + charcoal has performed the best and seemed to be used for sustainable water treatment option with additional profit and could supplement in various mitigation strategies to circumvent the global water scarcity.

Keywords: *floriculture, wet-lands, water scarcity, BOD*

Effect of Drip Irrigation Level and Micronutrient Application Method on Yield of Indian Mustard (*Brassica juncea* L.)

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An investigation entitled "Effect of Drip Irrigation Level and Micronutrient Application Method on Productivity of Indian Mustard (*Brassica juncea* L.)" was conducted at Agronomy farm, S.K.N. College of Agriculture, Jobner, District Jaipur (Rajasthan). Geographically Jobner is located at 75^{0}28' East longitude and 26^{0}05' North latitude and with an altitude of 427 metres above mean sea level in Jaipur district of Rajasthan. The region fall under Agroclimatic Zone IIIa of Rajasthan state named as Semi-arid Eastern Plains. A field experiment was laid out in split plot design with three drip irrigation level (0.4, 0.6 and 0.8 IW/CPE ratios) in main plot and four micronutrient application method (control, soil, foliar and fertigation) in sub plot and replicated four times. The results indicate that the grain and straw yield of mustard was significantly influenced by different drip irrigation levels and micronutrient application method. The drip irrigation level at 0.6 IW/CPE ratio recorded significantly higher seed yield (18.06 q/ha) and straw yield (66.31 q/ha) as compared to 0.4 IW/CPE ratio. The 0.6 IW/CPE ratio improved the seed and straw yield of mustard by 14.44 and 15.06 per cent over 0.4 IW/CPE ratio. In case of micronutrient application methods, fertigation observed significantly higher seed yield (19.73 q/ha) and straw yield (70.66 q/ha) over all other application method. The fertigation increased seed and straw yields by 39.23 and 25.30 per cent over control and 13.58 and 12.33 per cent over soil application. Foliar application also significantly increased seed and straw as compared to control and soil application. Henceforth, on the basis of this study, it can be concluded that the drip irrigation level at 0.6 IW/CPE ratio and micronutrient application through fertigation recommended owing to improved seed and straw yield of mustard as compare to other treatments besides proving itself economically viable.

Keywords: *Fertigation, mustard, irrigation, foliar application, yield*

Development and Performance Evaluation of a Human Powered Micro Sprinkler System through a Common Gym Cycle Utilizing the Harvested Surface Water

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A field experiment entitled "Development and Performance Evaluation of a Human Powered Micro Sprinkler System through a Common Gym Cycle Utilizing the Harvested Surface Water" was conducted at Department of Soil and Water Engineering, IGKV, Raipur. The aim of the experiment was improvisation of a common gym cycle for operating a micro-sprinkler system and its performance evaluation. The improvised system may become a boon for farmers who live in remote areas (usually small and marginal farmers), as electricity is a major issue for farmers and this system does not require electricity, solar or diesel power to pump water. Also it is eco-friendly, weather independent, economical, mobile and health friendly as cycling burns more calories, reduce extra body fat and makes heart, lungs and muscles strong. The system gave a discharge of 0.9 lps (3240 lph) at 2m of suction head which is good enough to efficiently irrigate the field area of about 300 to 400 m^2. The water on the earth is limited and ground water level is depleting. This demands for harvesting surface water as much as possible. Hence, the surface water flowing through the nallah is harvested by means of temporary water harvesting structure (Bori Bandhan) and its judicious use was also ascertained. Therefore, to irrigate the field modern system of irrigation (micro-sprinkler irrigation system) is was installed and its hydraulic performance has been evaluated to check the suitability of the improvised water pumping device for operating these micro-sprinklers. The system was installed in an area of 300 m^2 and divided into 5 plots (P_1, P_2, P_3, P_4 & P_5). Each plot consists of 2 lateral with spacing of 1.5 m containing 15 micro sprinklers arranged in a staggered manner on these two laterals. The performances of these micro-sprinklers have been evaluated in terms of its discharge, distance of throw, distribution pattern, uniformity coefficient and distribution uniformity. These values were found to be 2 lpm, 1.5 m, 75 % and 65 % respectively which are in the acceptable limits. Thus, from the findings of study it was concluded that at a time the improvised pumping system can easily irrigate the field area of about 300 m^2 and the micro-sprinklers operated by this improvised pumping system works efficiently.

Evaluation of impact of shifting sowing date of rice-wheat crops on groundwater behavior in Indo-Gangetic plain of north-west India

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This study aims to assess the impact of crop management practice on groundwater behavior using Visual Modflow Flex 2014.2 in Karnal district, Haryana, India. Approximately 85 percent of total land comes under agriculture of which rice and wheat are the major cropping system in the study area. Groundwater has become the major source to fulfill the crop water demand in district due to less extension of canal network as well as uneven occurrence of rainfall in last few decades. Thus, groundwater level is declining at fast rate. Now, it has become essential to adapt innovative sustainable management plan that could mitigate this problem. Therefore, shifting date of sowing crop management plan was made, in order to mitigate the steadily decline of groundwater level in the study area. Shifting date of sowing of rice and wheat crops plan were made for selection of the combination of best sowing date of rice and wheat crops that may less affect the groundwater resource. Five date of sowing i.e.15 June-5 Nov, 15 June-15 Nov, 25 June 15 Nov, 25 June-25 Nov and 5 July – 5 Dec of both crops were taken on 10 days of interval for evaluation of effect of shifting date of sowing on deep percolation and draft component. Recharge and draft were estimated from various land use while that was computed by using Aqua-Crop model from crop land. The calculated groundwater recharge and draft used for groundwater flow simulation and the change of groundwater level was predicted for corresponding combination of date of sowing using a numerical model Modflow. Model was calibrated successfully for transient condition for pre-monsoon data (May) for 2001-2010 period using trial and error as well as automatic calibration tool (PEST). Correlation coefficient and normalized RMS of the calibrated model was 0.98 and 6.54(%) respectively. Model was validated for 5 years (2011-2015) and good matching found between observed and predicated values of depth to water level. 15 June-5 Nov found best sowing date of rice and wheat crop that declined less groundwater level compared to other sowing dates. For 15 June-5 Nov, groundwater level declined to almost 18 m by 2018 in reference to water level of year 2001 followed by 18.85 m, 19.86 m, 18.95 m and 21.30 m in 25 June-15 Nov, 15 June-15 Nov, 25 June-25 Nov and 5 July- 5 Dec, respectively.

Keywords: *Groundwater, variable sowing date, Modflow and Aqua- Crop*

Use of extrapolated saturated front widths of line source field dripper method for more reliable estimate of unsaturated hydraulic conductivity function

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India has the largest area under drip irrigation. India with a total arable area of 140 m ha which is almost 42% irrigated, shows a great potential for micro-irrigation. The spacing between drippers and laterals are calculated using Gardener's unsaturated hydraulic conductivity function [K_h = Ks exp(1/λc)h]. λ_c is the scaling parameter and is inverse of α (relative measure of capillarity over gravity). Researchers proposed point source field-dripper method using Wooding (1968) steady-state water flow equation from a shallow circular pond for estimation of K_h. The area coverage by point source field dripper method is too small and subjected to error. Ojha et al. (2020) proposed line source field dripper method for K_h estimation. It cover large area hence provides accurate and representative value of K_h. The have used steady state saturated front widths for measurement of K_h. One hour may not be sufficient to reach steady state saturated conditions. Extrapolation of saturated front width beyond 60 minutes till a steady state is reached could be used for correct measurement of K_h. This is the first work of its own kind for estimation of accurate Ks and α using an implicit relationship.

Experiments were conducted at office premise and adjoining area of Shivri Research Farm of ICAR-Central Soil Salinity Research Institute Regional Research Station, Lucknow for getting steady state saturated front width against different line source discharge rates. Measurements of saturated front width was made after 2, 5, 10, 20, 30, 40, 50, and 60 min at five equidistant locations for line source dripper discharge rates of 109.5, 127.8, 164.3 and 273.8 cm^3 /h/cm on cultivated recently tilled normal soil (CRTNS); 109.5, 127.7, 164.2 and 255.5 cm^3 /h/cm on cultivated untilled normal soil (CUTNS); 91.25, 109.5, 146.0 and 218.6 cm^3 /h/cm on cultivated recently tilled sodic soil (CRTSS), and 109.5, 127.75, 164.25 and 200.75 cm^3 /h/cm on uncultivated untilled sodic soil (UUTSS) respectively. Saturated wetted front width was extrapolated upto 210 minutes using relationship $y=a(1-e^{-bx})$ and used for calculation of K_h function. The values of K_s obtained with 60 minute saturated fronts were 4.08, 3.18, 1.77 and 0.426 cm/hr for CRTNS, CUTNS, CRTSS and UCUTSS, respectively while the corresponding values were measured as 3.29, 2.81, 1.55 and 0.408 cm/hr. The Ks values obtained by extrapolated saturated width were 19.36, 11.64, 12.43 and 4.22% lower than the values obtained by 60-minute saturated front widths. The α values obtained using extrapolated saturated front widths were 0.07, 0.076, 0.066 and 0.0038 cm-1 and with 60- minutes saturated fronts were 0.10, 0.10, 0.10 and 0.004 cm-1 for CRTNS, CUTNS, CRTSS and UCUTSS, respectively. The values of α obtained with extrapolated saturated front was lower than the values obtained with 60-minute saturated fronts. Use of extrapolated saturated front widths for measurement of K_s and α seems more reasonable and appropriate hence recommended for further field applications.

Keywords: *Field dripper, line source method, point source, unsaturated hydraulic conductivity*

Solid Industrial Waste as soil amendment and its effect on performance of Wheat and Chickpea on Vertisol of Gujarat

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Field experiments were conducted on black soil at CSSRI, RRS, Bharuch (Gujarat) with wheat and chickpea to ascertain the response of bio-sludge (BS) alone and in combination with and vermicompost (VC) to test the efficacy of biological sludge in supplying nutrients and its effect on crop growth and yield as well as on soil properties. The bio-sludge is the solid waste generated from fertilizer plant of GNFC-NCPL, Bharuch (Gujarat) and there is problem for its disposal.

The application of bio-sludge increased the grain yield of wheat (KRL 238) was to the extent of 22.8, 26.2 and 7.2 per cent over control in first, second and third years, respectively. The wheat variety NW 3087 showed increase of 11.4, 2.0 and 9.0 per cent increase in grain yield when bio-sludge was applied with NPK over NPK alone.

Application of bio-sludge in combination with vermicompost and NPK showed increase of 44.5, 46.4 and 17.6 in KRL 238 while 30.8, 29.4 and 21.9 per cent in NW 3087, respectively in three years over NPK alone.

In chickpea, application of bio-sludge (BS) along with NPK resulted in increase of number of pods/plant to the extent of 16 pods/plant which further got enhanced to the magnitude of 30 pods per plant when BS+VC were applied in conjunction with NPK. Similarly, number of seeds per plant was increased by 210% in NPK+VC treatment and by 115% in BS+VC treatment as compared to 70% in NPK+BS treatment over control.

The weight of 100 seeds was maximum of 16.05 which obtained in treatment where BS+VC were applied while minimum in control (NPK). The seed yield of chickpea was increased by 16 and 26 per cent over control when BS alone and BS along with VC was applied.

The effect of bio-sludge on soil bio-chemical properties was found to be pronounced in terms of supply of additional N and S as well as improving microbial activity. However, the effect was much higher when VC was added in conjunction with bio-sludge. The study conducted thus indicated that the use of biological sludge can be an alternate source for sustainable management of lands for production of crops.

Keywords: *Bio-sludge, solid waste, vermicompost, wheat, chickpea*

Livelihood promotion and nutritional security through soil and water resource & management in NICRA Village of Banka District

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The study was conducted in NICRA adopted village Merha of Banka District. NICRA project was launched in this village in 2015-16 with the objective to enhance livelihood promotion and livelihood security by adopting climatic resilience technology as a rain fed situation. Study was conducted by adopting survey method after two years of intervention. Rice is the major crop of the village in kharif season, drought tolerant paddy variety Sahbhagi Dhan was introduced in 80 farmer's field in 29 ha area. This variety proved successful in yield and advancement in sowing of rabi crop 15-20 days. The highest grain yield 32.67 qu, and B: C Ratio 2.05:1 was recorded more and significantly superior in Sahbhagi Dhan as compared to local cultivar 1.56:1. The yield attributes *ie.*, dry matter accumulation/hill at harvest, panicle length, panicle weight, leaf area index recorded more and significantly superior as compared to local cultivar. Zero tillage technology was demonstrated among 15 farmers' field in 3 ha area in NICRA village with the objective of enhancing production and productivity of the crop in rain fed situation and mitigate the natural calamities as a moisture deficiency by prolonged dry spell. The net return was recorded Rs. 38160/- per ha for wheat and 40166 Rs./ha for paddy. B: C ratio was recorded 2.46:1 and 2.48:1 in wheat and paddy, respectively. Under in situ moisture conservation technique, 3 ha area was enhanced through cleaning old water channels. 3 ha area of 18 farmers were leveled converting waste land into cultivable land and 01 ha land of 9 farmers have been managed by bunding. The farmers started growing mustard and potato as rabi crop with new introduction of chick pea in the village. Different cereal and leguminous fodder crops with stylo and clitoria as perennial grass in barren land. Green fodder feeding increased the milk yield by 1.5-2.0 kg/day/animal. Licking of UMMB 300g/day/animal increased milk production 600-700g/day/animal as well as earlier conception, less repeat breeding. UST bag was introduced in two progressive farmers of the village, revealed that the cost of treatment of straw was 0.84 Rs/kg decreases the concentrate intake by 1.2 kg/animal/day which saves Rs. 6884/- per calving period and net saving Rs. 10817/- per animal/inter calving period. Although, farmers adopted these technology of natural resource management, crop production, livestock production management as a precise manner and integrated form to mitigate the calamity of unfavorable abiotic factors for their livelihood security. Demonstration done amongst farmers field which has been recorded significantly more beneficial in terms of yield and income both as compared to traditional practices in this village.

Keywords: *Sahbhagi paddy, water channel, UMMB and urea treatment*

Scientific approach for conservation of soil and water resources and its managements

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Soil and water are the essence of life and are essential for food production. It is a known fact that the soil and water is affected directly or indirectly by many natural and artificial processes. Thus, there natural resources must be used in such a way as to protect, enhance and restore its functions. Soil and water conservation is a worldwide strategy in the context of a sustainable and poverty-orientated natural resource management. The main objectives of soil and water conservation are to obtain the maximum sustained level of production from a given area of land by preventing soil degradation and environmental pollution. Therefore, soil conservation practices usually aim at the primary causal factors and areas. For example, reducing or protecting bare areas or exposed soil and reducing the rate of run-off. Timing in implementation of soil conservation measures is also important in plantation tree crops, as the highest risk of erosion usually occurs in specific period such as during planting or replanting and monsoon season. Some of the soil conservation measures are- Terrace farming, Establishment of leguminous cover crops, Maintaining ground vegetation, Mulching with empty fruit bunches, Silt pits etc. The sustainability implies maintenance and enhancement of soil quality through judicious land use, recommended soil management practices and conservation effective measures. There are some soil management practices for adaptation to climate change like judicious management of soil to restore its quality can enhance its resilience to extreme events (e.g. drought, heat wave etc.) and uncertain and variable climate. Water is the most basic resource to sustain the life on earth as well as for better crop production in agriculture. Large part of our country has already become water stress so its proper management is very essential in now- a- day. Some of the water management approaches are rain water harvesting, artificial ground water recharge, treatment of chemically and biologically contaminated ground water resources in rural areas for provision of safe potable water, treatment of domestic/industrial effluents and recycling of usable water for irrigation and commercial purpose thereby diverting the water used in these areas for domestic consumption. Majority of total consumption of water is utilized for irrigation purpose in agriculture out of which drip irrigation, sprinkler irrigation is found to be more efficient one where wastage of water is minimum and also helpful in increasing productivity of land or soil. The main challenge is low public consciousness about the overall scarcity and economic value of water as well as soil results in its wastage and inefficient use. Therefore, a general awareness about its management is needed to be created and the community must actively involve itself in it for its sustainable development.

***Key words**: Importance of soil and water, Soil conservation, Water management, challenges*

On-farm composting of municipal solid waste for restoration of degraded sodic lands and sustaining crop yield

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A research to overcome hazardous problems due to municipal solid waste (MSW) was developed by means of on-farm MSW compost and industrial processed MSW compost and their use in combination with inorganic amendments to restore degraded sodic soils and sustaining crop productivity. Seven treatment combinations with two decomposing agents like earth worms (*Eisenia foetida*) and cellulose and lignin degrading microbes (*Aspergillus spp.*, *Trichoderma spp.* and *Bacillus spp.)* Amongst the treatments tested for producing on-farm quality compost treatment T_7 using 50% degradable MSW + 50% agricultural waste enriched with earthworms and microbes (T_7) produced cost effective and nutrient rich quality compost. This compost was used in combination with inorganic amendments with eight treatment combinations in a highly sodic soil (pH 9.8± 0.10, EC147µSm^{-1}±12.0,ESP±2.50) to monitor the combined effect of organic and inorganic amendments on soil amelioration and crop productivity. The study revealed that combined application of gypsum or phosphogypsum @25% gypsum requirement (GR) + on-farm MSW compost @10Mg ha^{-1} showed a significant improvement in soil physico-chemical and microbial properties and enhanced 4% and 12% rice and wheat grain yields respectively over the recommended practices of gypsum/phosphogypsum @ 50% GR. Adoption of this approach saved about US$ 433 ha^{-1} on account of reclamation cost by reducing gypsum/phosphogypsum dose from 50% GR to 25% GR with the addition of MSW compost and sustained crop productivity in degraded sodic soils.

Key words: *On-farm composting; municipal solid waste compost; agricultural wastes; inorganic amendments; restorationof degraded sodic lands; crop productivity*

Bioremediation of soil and water resources by mushrooms for conservation and management of environment

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The major environment problems today are the contamination of soil, water, air by toxic chemical and use of pesticides in agriculture. These chemicals include polycyclic aromatic hydrocarbon, ethane, pentachloro - phenol, benzene, toluene, polychlorinated biphenyls, toluene, trinitrotoluene. Bioremediation concerning ability of mushroom and their enzymes to bio-transform pesticide. It is now becoming that mushroom play an important role in degrading organic materials in the ecosystem and have potential for remediating contaminated soil and water. Mushroom forming fungi are amongst nature most powerful decomposer. They secreting strong extra- cellular enzymes due to their aggressive growth and biomass production. These enzymes include lignin peroxidases, manganese peroxidase and laccase etc. The process of using microorganism to remove organic wastes, prevent pollution, or for environmental clean-up. Bioremediation depend largely on the enzymatic activities of living organism, usually microbes, to catalyze the destruction of pollutants or their transformation to less harmful forms. The fungi to decompose the contaminants, finally to CO_2 and H_2O. *Phanerochaete chrysosporium, Agaricus bisporus, Trametes versicolar, Pleurotus ostreatus etc.* have been reported in polluted sites. The contaminated are unfit for agriculture could be both cleaned and made to yield a nutritious food crop.

Keywords: *Mushrooms, Chemicals, water and soil*

Estimation and validation of empirical models for soil wetting front under point source of surface drip irrigation

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Accurate information about the wetted dimensions of soil under point source of surface drip irrigation helps designers to determine optimal design, operation and management by combination emitter flow rates and spacing between emitter and laterals to reduce system equipment costs and provide better soil water conditions for the most efficient and effective use of water. The wetting pattern dimensions under point source of surface drip irrigation can be measured in laboratory, field or estimated by modelling. In this study, a comparison was conducted between five empirical models for estimating the wetted pattern dimension. With field observed data was used to evaluate the empirical models of Schwartzman and Zur, Le et al. Amin and Ekhmaj, Malek and Peters & Al-Ogaidi et al. model. Statistical comparisons (mean error, root mean square error, and model efficiency) are made of the simulated data with the observed field data. The results performed that the suggested equations can be used for a wide range of discharge rates and soil types. The best result was obtained from the Al-Ogaidi et al. model in this investigation. The lowest mean error, and root mean square error for the wetted radius 0.41 and 0.64 cm & for wetted depth was 0.51 and 0.88 cm, respectively. It can be used in design and management of drip irrigation systems.

Comparative Evaluation of various NDVI Models to estimate Crop Co-efficient for Summer Sesame

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An attempt has been made to estimate crop co-efficient from different NDVI models and compare them for summer sesame based on single crop coefficient approach for South Gujarat Agro Climatic Zone of Gujarat state. Field experiment was conducted at college farm, CAET, NAU, Dediapada, during summer season of 2019. The NDVI data was estimated using FieldScout CM 1000 NDVI Meter. The NDVI data from the soil and crop was collected on weekly basis. The FAO crop co-efficient data was taken from FAO irrigation and drainage paper no. 56. There were two different water application systems used and these are drip irrigation system and surface control irrigation system. The NDVI data collected from both systems separately. Also The FAO crop co-efficient data was taken separately for both systems. The crop co-efficient was directly estimated from NDVI value using NDVI-Kc Models. There were four different models are used in study. The stage vise average NDVI data estimate from the weekly NDVI data. The stage vise crop co-efficient was derived from the stage vise average NDVI data for each model separately. The NDVI-Kc models contain a linear equation. This stage vise crop co-efficient data of different models for drip and surface irrigation system were compare with the FAO crop co-efficient data for both systems. From the all comparison the R-square values for Muttibwa & Irmak, Kamble, Singh & Irmak and Vashisht models are 0.918, 0.926, 0.930 and 0.868 for drip irrigation system and 0.840, 0.850, 0.857 and 0.856 for surface control irrigation system respectively.

Keywords: *FAO 56, NDVI, crop coefficient, Drip irrigation system, Surface Control irrigation system, NDVI-Kc Models.*

Crop intensification with pulses in coconut garden for safeguarding food security in the state of Kerala

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With the burgeoning population, India has been pushed from 83rd rank in 2000 to 102nd rank in 2019 on Global Hunger Index and is far behind most of the neighbouring countries out of 119 countries enlisted. Rapid urbanization and its encroachment on agricultural land is a consequence of increase in population (Lal, 2018). As land expansion is limited to meet the ever-growing population, there is a need to increase production per unit area. Pulses fit well in intercropping, crop rotation and crop mixture in any of the cropping systems of the tropics. Coconut (*Cocos nucifera*), popularly called as Kalpavriksha (Tree of heaven) is one of the major plantation crops in India with a total cultivated area of 1975.81 thousand hectares with a production of 21,665 million nuts which makes India stand 3rd in the world contributing to India's GDP of about 15,000 crore rupees. In Kerala, coconut garden accounts for an area of 7.9 lakh ha wrong figure with a production of 7432 million tonnes and a productivity of 7432 (GOI, 2019). In coconut plantations of above 40 years, light transmission increases about 50 per cent which makes growing of intercrops possible in the interspaces. The active root zone of coconut is confined only to 25 per cent of the available land area. So, the interspaces in coconut garden can be effectively utilized for growing crops which are suited for that area. Pulses are nature's amazing gift with unparalleled abilities like deep root system, biological nitrogen fixation, mobilization of insoluble soil nutrients as well as soil fertility restorers as they bring qualitative changes in soil properties thereby protecting the environment (Kumar *et al.*, 2018). They have immense potential to satisfy the growing human food demands, for improving human health, conserving soil, protecting the environment and contributing global food security. Growing short duration pulses in the coconut garden has numerous advantages like utilization of available space in between coconuts, additional income to the farmers, enhancing the soil fertility and ensuring food and nutritional security. Ravindran (1997) explored the nutrient-moisture-light interactions in a coconut-based cropping system and reported that cowpea could be raised successfully and economically as intercrop in coconut garden applying half the recommended dose of N and P and full dose of K without much competition for nutrients, moisture and light. In a study conducted to evaluate black gram varieties suited for cultivation under shaded situations in coconut garden, DBGV 5 (released from University of Agricultural Science, Dharwad) and Sumanjana (released from Kerala Agricultural University) varieties were found promising recording appreciable yield.

Keywords: *crop intensification, pulses, coconut*

Impact of weed management practices on weed indices and yield of Bajra Napier hybrid in Kerala

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The study entitled "Weed management in Bajra Napier hybrid (Pennisetum glaucum x Pennisetum purpureum)" was carried out during 2019-20, at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala with an objective to standardise an economic weed management strategy for Bajra Napier Hybrid. The experiment was laid out in randomized block design (RBD) with 9 treatments in three replications. The treatments were oxadiargyl 60 g ha^{-1} on 3-5 DAP fb carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP, oxadiargyl 90 g ha^{-1}on 3-5 DAP fb carfentrazone ethyl 20 g ha^{-1}on 25-30 DAP, oxadiargyl 120 g ha^{-1} on 3-5 DAP fb carfentrazone ethyl 20 g ha^{-1} on 25-30 DAP, oxadiargyl 60 g ha^{-1} on 3-5 DAP fb hand weeding on 25 - 30 DAP, oxadiargyl 90 g ha^{-1} on 3-5 DAP fb hand weeding on 25 - 30 DAP, oxadiargyl 120 g ha^{-1} on 3-5 DAP fb hand weeding on 25 - 30 DAP, biomulching, farmers practice (hand weeding at 20 and 40 DAP and weedy check. The variety used for the study was Suguna, released from Kerala Agricultural University. Weed management practices had significant effect on weed characters as well as growth and yield of the crop. The treatment oxadiargyl 90 g ha^{-1} on 3-5 DAP fb hand weeding on 25 - 30 DAP recorded the lowest weed count, density, dry weight, weed index and the highest weed control efficiency, green fodder yield and dry fodder yield. An increase of about 47.14 % in green fodder yield was recorded with application of oxadiargyl 90 g ha^{-1} on 3-5 DAP fb hand weeding on 25 - 30 DAP over weedy check. Hence considering the growth and yield of the crop, application of oxadiargyl @ 90 g ha^{-1} on 3-5 DAP fb hand weeding on 25-30 DAP could be adjudged as an effective weed management practice in Bajra Napier hybrid.

Keywords: *Bajra Napier hybrid, Dry fodder yield, Green fodder yield*

Cropping intensity Management in Kushinagar

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KVK, Kushinagar assessed the technology of intensification and diversification of irrigated rice-wheat cropping system at 5 farmers field .Cropping intensity of district Kushinagar i.e. 155.25 % due to sugarcane as sole crops in a years , in case of rice –wheat system only 200% . During Kharif season Rice var P-2511 gave 40.25 q/ha in 125 days in comparison to farmers practice i.e. BPT-5204 gave 22.75 q/ha in 147 days due to dry spell and un scattered rainfall and save 20 days of cropping period so that in rabi season farmers take 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 i.e. Wheat var. HUW-234 gave yield 20.15q/ha due to delayed in sowing due to delay harvesting of paddy and preparation of land. During Zaid season farmers sown Cowpea variety Kashi Kanchan after harvesting of Toria as vegetables crop. In the trial T_1 cropping intensity increased 300 % (Paddy var.P-2511- Toria var. PT-303/Uttara- Cowpea var. Kashi Kanchan) in comparison to farmers practice i.e.200 % (Paddy var. BPT-5204- Wheat var HUW-234- followed by fallow land). Other parameters presented in table which is given below.

Keywords: *Intensification and diversification*

Ecological Response to River Sedimentation: ANN based approach

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Regulation of river discharge, forced by uneven distribution of rainfall in India, and introduction of a large amount of polluted water as industrial waste, sewage water and seepage from agrarian lands has made proper care of river ecosystem as a national responsibility for sustaining the terrestrial and aquatic ecology. In this study, sediment estimation was carried out for the Godavari river and the effect of the sediment on the river ecology was illustrated. Daily runoff and sediment concentration (SC) data (from 1990 to 2016) collected at Mancherial gauging station were utilized as input dataset. Gamma test (GT), M-test and cross correlation function (CCF) were utilized for appropriate input selection, selection of training data length and sensitivity analysis, respectively. Artificial neural network (ANN) were used for SC estimation and their performances were evaluated on the basis of correlation coefficient (r) root mean square error (RMSE), coefficient of efficiency (CE). On the basis of GT, runoff of current day, previous one day, previous two day, previous three day, SC of previous one day and two day as input were selected but after analysing the sensitivity of SC with input variable using CCF, input variables were optimized to four (namely runoff of current day, previous one day, previous two day and sediment of previous one day). After comparing results ANN and ANFIS models it was found that ANN model (4-16-1) with single hidden layer, sigmoid activation function and Levenberg-Marquart algorithm performed better than other single and double hidden layered ANN models. Erosion from agricultural land resulted not only loss of fertile soil but also contributes many problems like deposition on river bed consequently loss of river flow capacity, siltation of dam, increases BOD of river system etc. In this study, an attempt ha been made to analyse the impact of sediment on the river ecology. It was concluded that clay and silt particle bring many chemical impurities to the river which makes water unsuitable for drinking, fisheries, industrial use, livestock watering and also for irrigation.

Keyword: *ANN, GT, M-test, CCF, River ecology*

Evaluation of Cow-Based Organics for Non-Insecticidal Pest Management in Castor

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Castor, *Ricinus communis* L., is an important industrially valued non edible oilseed crop and is grown especially in arid and semi-arid regions. India is the largest producer of castor seed and oil, which account for 5% area and 64% production in the world. Castor crop suffers from many biotic stresses and among them sucking insects and foliage feeders are of economic importance. The control of insect pests in rainfed castor mainly involves pesticides and only very rarely do farmers use cultural, physical or biological methods. The use of suitable cow-based organics against defoliators and sucking pests in castor will reduce the cost of plant protection and reduce environmental pollution. The information on environmentally safe, non-pesticidal pest management options in castor under rainfed condition is scanty. Hence, present study was taken up to identify the best cow based organic alternatives for non-insecticidal pest management in castor at the research farm of ARS, Drasi, Prakasam district of A.P. during Kharif, 2017. Popular castor hybrid, PCH 111 was sown in RBD having uniform plot size of 7.0 m x 6.0 m with a spacing of 90x60 cm and the treatments include Neemastra @ 20 ml/l, Bramhastra @ 20 ml/l, Agniastra @ 20 ml/l, NSKE (organic check) @ 5%, Acephate (Ist spray) followed by Thiodicarb (IInd spray) @ 1 gm/l each and water spray as untreated check. The treatments were imposed twice during first week of October and November when infestation crossed above economic threshold level. The investigation revealed that NSKE 5% was found superior in controlling insect pests of castor. Cumulative mean of two sprays of NSKE 5% recorded least no. of larval population of semilooper (1.1 larvae/plant), Spodoptera (0.8 larvae/plant) and capsule damage caused by capsule borer (17.0%) and was next best to recommended insecticidal check treatment (0.7, 0.7 and 11.7%, respectively). All the cow based organics *viz.*, neemastra, brahmastra and agniastra recorded lower populations of semilooper (2.3, 2.9 and 2.7 larvae/plant, respectively), Spodoptera (2.4, 2.7 and 2.4 larvae/plant, respectively) and capsule damage by capsule borer (24.2, 26.8 and 23.6%) compared to untreated control which recorded larval population of 4.14 semilooper/ plant, 4.42 spodoptera/ plant and 35.0% capsule borer damage. However, all the organics including insecticidal check were at par in recording leaf hopper population (2.3 to 3.0 per leaf) but superior to untreated control (3.6 per leaf). NSKE 5% followed by neemastra, brahmastra and agniastra conserved highest population of coccinellids (1.3, 1.1, 1.0 and 0.9/plant), spiders (1.0, 1.0, 1.0 and 0.7 /plant) and Microplitis coccons (1.3, 0.6, 0.4 and 0.3/plant) and were at par with untreated control (1.5, 1.3 and 1.5/plant, respectively). Insecticidal check treatment fails to conserve much population of natural enemies in castor ecosystem. NSKE 5% recorded higher seed yield of 7.4 q /ha and was next best to chemical check which recorded 8.9 q/ha. Among the cow based organics, agniastra recorded 4.7 q/ha followed by brahmastra (4.2 q/ha) and neemastra (3.9 q/ha) and were bit superior to untreated control (3.6 q/ha). The highest incremental cost-benefit ratio of 16.4 and 10.2 was recorded in treatment schedule comprising two sprays of NSKE 5% and acephate followed by thiodicarb, respectively. Among the cow based organics, two scheduled sprays of agniastra recorded higher ICBR of 3.4 compared to other organics.

Keywords: *Castor, cow based organics, NSKE, sucking and defoliator insect pests*

Identifying hydrological response units (HRUs) for the west Banas river basin of Rajasthan state

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Hydrological studies in basins are important because, they help to understand processes that control water movement and the likely impacts on water quantity and quality. In this sense, the quantitative understanding of hydrological parameters (rainfall and runoff) and it's spatial and temporal variability in regions or river basins seen as crucial to efficient a planning and management of water property. This follow a line of investigation study involves identifying hydrological response units (HRUs) for the West Banas River Basin of Rajasthan State by using GIS and SWAT model. The study report generated information regarding its elite physical characteristics: land use, soil type and slope classes to the altitude of every HRU enclosed by the sub-watershed. It can be realistic that the widespread type definition generated one solitary HRU in all sub-watersheds. The study showed that, the field-based HRU delineation strength is quite diverse from the standard approach due to choosing a preponderance soil type in each farm field. This come within reach of is flexible such with the purpose of any land use and soil data prepared for SWAT can be used and any shape file boundary can divide HRUs.

Determination of Quantum Recharge Requirement by Utilizing Spatial Data for Revival of Kanari River

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A 'river system' necessarily includes the 'morphology' of the river as well as 'connectivity' which is defined as the way in which different landscape compartments fit together in the catchment (Brierley et al. 2006). A scientific and global intervention and approach to tackle such challenges to river management in India requires a highly multidisciplinary approach, which must be process-based and predictive. The study was planned at Kanari river originating from Ghutehi hill region located at Ghutehi village (Sihora Tehsil) in Jabalpur district of Madhya Pradesh (23°33′36.73″N and 80°06′57.49″E) at an elevation of about 490 m. For the study, satellite image of Sihora Tehsil, Jabalpur District, covering Kanari River Watershed were acquired for four Epochs: 1990, 2004, 2009 and 2019 from Global Land Cover Facility (GLCF) an Earth Science Data Interface. To prepare the LULC map from satellite imageries, a classification scheme which defines the LULC classes was considered. Eight major LULC classes were chosen for mapping the entire watershed area viz; water body, agricultural land; forest/mountain, wasteland, open field, mines, habitat and vegetation for the year 1990, 2004, 2009 and 2019. The classification method used for this project produced an overall accuracy of 93.4% which finally interpretated contrasting percentage of various classes that resulted in drying of the river. The result indicated that the habitation and mining activities were increased by 99.48% and 68.10% (form the year 1990 to 2019) respectively which consequently enhanced the groundwater overdraft. Further analysis showed that the forest (63.1% decrease), vegetation (64.48% decrease), water body (92.09% decrease) acreage were converted into waste land (90.61% increase), agriculture field (53.08% increase) resulted in shifting of the origin of the river. The runoff in the study area was also calculated by the integration of ArcGIS and SCS-CN method which finally depicted the runoff in the area kept on increasing as rainfall kept on increasing following a linear trend which predicted that the infiltration opportunity decrease and ultimately resulting in decreased infiltration rate causing decreased baseflow resulted in drying of river. Various questioner surveys were also conducted which indicated that direct uplifting of water from the stream for irrigation purpose is root cause of the problem.

Keywords: *Thematic Map, LULC, SCS-CN method, satellite imagery*

Efficacy of Kafal (*Myrica esculanta*) leaves extract as bioadsorbent in reducing copper ion concentration from aqueous solution

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Various environmental pollutants such as metals, pesticides, and other organics pose serious risks to many aquatic organisms. These pollutants disturb physiological mechanisms and causes toxicity in animals exposed to contaminants. Although copper is an essential trace element in all living organisms as it participates in different metabolic processes and maintain functions of organisms, but its excessive amount stimulates free radical production in the cell and may cause physiological and biochemical alteration which leads to mortality. The commonly used remediation processes for heavy metals removal from contaminated wastewater are chemical precipitation, carbon adsorption, electrowinning, reverse osmosis, preconcentrations, bioadsorption, phytoremediation etc. Among these, bioadsorption is comparatively efficient, economical, low cost and reliable method. The reliability of this method depends on the availability of local bioadsorbents and their abundance. *Myrica esculenta* belongs to the family Myricaceae is a sub-temperate evergreen tree found throughout the mid-Himalayas, starting from about 1,300 meters and going up to about 2,100 meters. The plant leaves of Kafal were collected from Kumaun region of India. Leaf extract powder of Kafal acts as an efficient bioadsorbent for Cu (II) ions removal of from contaminated wastewater under batch study. The removal efficiency of the metal ion is very rapid during initial phase and a large fraction of the total amount of metal ion was removed within a few minutes. But after 80-90 minutes the uptake rate of metal ion on bioadsorbent was not rapid and become about constant. It is due to the saturation of available binding sites within metal ions. So, less contact time is required for the interaction of metal ion and bioadsorbent and its influence on adsorption capacity.

Keywords: *Bioadsorption, Contaminants, Kafal, Mortality.*

Farming System Approach for Food Security and Sustained Rural Economy

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Agriculture production is a backbone of Indian economy. The size of agricultural land holding is decreasing by increasing Indian population as well as the expansion of urbanization and industrializations. This situation creates a serious problem in agriculture sustainability and food security. Over a period of time, researchers and farmers are more focus on crop production without consider the integrated farming system (IFS). This is a serious challenge to the stability and profitability of the agriculture production. The Sustainable Rural Livelihood concept offers a more logical and integrated approach to poverty mitigation. To attain sustainable rural livelihoods, different livelihood capital such as natural, social, human, physical and economical would play a better role to manage with natural shocks and stresses and sustain or improve the individual capability and resources both in present and future without degrading the natural resource base. stated that "there is no waste and waste is only a misplaced resource which can become a valuable material for another product" in integrated farming system. In another words, IFS concept as a type of mixed farming system that is combines crop and livestock enterprises in a supplementary and complementary. The difference between mixed farming and integrated farming is that farm enterprises in the integrated farming system are mutually supportive and depend on each other, IFS as concept of minimize risk, increasing production and net profit along with improving the utilization of farming wastes and crop residues. The basic concept of IFS is complementary and synergies effect between animal component and crop. The combination usually occurs when the outputs (usually byproducts) of one enterprise are used as input for another enterprise within the perspective of the farming system. The farming system approach is helpful in increasing the farm income and employment opening for rural population and also protects the natural resources in the course of recycling of the crop residues and animal wastes used within the farm itself.

Keywords: *Integrated, Sustainable, Mitigation, Enterprises, Resource*

Intensity of Soil Use and Organic Carbon Fractions in a Montanous Ecosystem

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Soil, an important natural resource, provides food, fibre and shelter to mankind and also does ecological services. Among many eco-services of soil, carbon sequestration is an important service with reference to climate change mitigation for the restoration of ecological balance. Organic carbon forms a vital component in soil and has link with all soil properties and also sequester atmospheric carbon dioxide. Estimation organic carbon storage with its different fractions under different land uses gives ample scope for further sequestration. Soil organic carbon consisted of many fractions from very labile to recalcitrant based on their microbial decomposition. Every fractions of OC has importance in maintaining soil productivity and carbon dioxide emission in any agroecosystem. We planned a study on soil organic carbon fractions under different intensity of soil use in mountain ecosystem of Western Ghats. We have collected surface and profile soil samples at three land uses such as Shola forest, tea plantation and agriculture. Surface soil sample collected at 0-30 cm depth and in profile its was upto 60 with 15 cm increment from the surface. Surface soil sample collected randomly at 10 places and profile samples collected three places in each land uses. Soil samples were analysed for five fraction of soil organic carbon namely, Very Labile Carbon (VLC), Labile Carbon(LC), Less Labile Carbon (LLC), Recalcitrant Carbon(RC) and Water Soluble Carbon(WSC) with standard procedure. VLC fraction of soil recorded with 1.43, 1.22 and 0.87 per cent in Shola forest, tea plantations and agriculture respectively. The LC fractions was observed with 1.05, 0.49 and 0.19 per cent respectively at Shola forest, tea plantations and agriculture. LLC fraction was 0.60, 0.31 and 0.15 per cent with Shola forest, tea plantations and agriculture respectively. The RC fraction was observed 1.52, 1.31 and 0.61 per cent in Shola forest, tea plantations and agriculture respectively. Water Soluble Carbon recorded 3.54, 3.11 and 2.01 per cent respectively at Shola forest, tea plantations and agriculture. Higher organic carbon content was recorded at Shola forest because of its undisturbed condition followed by tea plantation due to limited disturbance and lowest in agriculture due to severe disturbance of soil. We have more scope to sequester atmospheric carbon in soil under agriculture followed by tea plantation which mitigates global warming problem and restore ecological balance.

Keywords: *Montanous ecosystem; soil use intensity; soil organic carbon fractions; eco-restoration*

Soil Organic Carbon Fractions in Fresh Water Swamps of Southern hilly Region

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Swamps are the wetlands develop in valley or depressions become important unit of ecosystem. Western Ghats mountain is receiving heavy rainfall and the valleys are developing swamps under various land uses. Swamp stores heavy amount of organic carbon by deposition from its catchments and act as carbon sink. In this study, three swamps (Mixed forest swamp, Grassland swamp and Agricultural Swamp) were selected in Nilgiris, part of Western Ghats, to study the organic carbon storage. All the swamp covered with *Juncus glaucus* the rush, as vegetation, in all the swamps followed by Cyprus spp. Ten samples from the swamps and its upland, at different spots of entire region were collected. The biochemical properties of swamp soil, and respective upland soils were studied. Under biochemical properties, soil organic carbon fractions such as Very Labile, Labile, Less Labile, Recalcitrant and Water-Soluble fractions were estimated in all three swamps. The swamp soil of forest recorded the Very Labile Carbon (VLC) of 2.26 per cent and in its catchment soil of 1.93 per cent. In grassland swamp soil, it was 3.97 per cent whereas in its catchment it recorded 1.87 per cent. In agricultural swamp soil, the VLC was 1.99 per cent and in its catchment, it was 1.34 per cent. VLC was found highest in grassland swamps and forest uplands soils. Labile Carbon (LC) recorded 0.96 per cent forest swamp soil and in catchment soil it was 0.55 per cent. In grassland swamp soil, the LC was 1.76 per cent where as in its catchment it was 0.93 per cent. In agricultural swamp soil, the LC was 0.78 per cent and in catchment it was 0.26 per cent. LC was found highest in grassland swamps and its upland followed by forest and agriculture. The swamp soil of forest recorded higher quantity of LLC with 0.45 per cent and catchment soil with 0.61 per cent. In grassland swamp soil, the LLC was 0.65 per cent where as in its catchment it was 0.86 per cent. In agricultural swamp soil, the LLC recorded 0.33 per cent and in the catchment it was 0.32 per cent. LLC was found highest in grassland swamp followed by forest and agriculture. The swamp soil of forest recorded higher quantity of NLC of 1.50 per cent and catchment soil with 1.26 per cent. In grassland swamp soil, the NLC recorded 1.65 per cent and in its catchment it was 1.24 per cent. In agricultural swamp soil, the NLC was 1.33 per cent and in its catchment it was 1.27 per cent. The swamp soil of forest recorded higher quantity of WSC was 3.90 per cent and catchment soil it was 3.63 per cent. In grassland swamp soil, the NLC was recorded with 5.32 per cent and in its catchment it was 4.91 per cent. In agricultural swamp soil, the NLC recorded with 3.61 per cent and in its catchment it was 2.14 per cent. We found that the organic carbon fractions were found more in swamp soil than the catchment soils. Among three swamps grassland swamps stored more organic carbon followed by forest and agricultural swamps. Though soil and carbon losses are more in hilly ecosystem, the swamps are effectively storing organic carbon as a sink and reduce carbon dioxide emission.

Keywords: *Hilly ecosystem; land uses; swamps; organic carbon storage*

Effect of Forest Land Covers on Soil Organic Carbon Stocks in Southern Hilly Region

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Land cover management decides effectiveness of conservation of natural resources especially soil and water. Permanent vegetation with high biomass, such as undisturbed dense forest, is considered to be a most efficient land cover to conserve natural resources at maximum possible. Natural resources found in hilly regions are highly fragile and the variations in vegetation density of forest cover may cause differences in conservation soil and its quality. Effective land cover with high density of vegetation reduces the losses of soil, water, organic carbon and nutrients. Organic carbon content in soil is a reliable indicator to judge the relationship between soil erosion and conservation. Hence, organic carbon stocking capacity of soil has direct relationship with soil erosion. An assessment study was done in the Nilgiri hills district of Western Ghats for soil organic carbon stock under different forests covers of lower altitudes <1000 msl such as tropical evergreen, dry deciduous, teak and bamboo forests. The Nigiri district consists of 57 % area under forests. Representative sits were selected for profile soil sampling up to one-meter depth with 15 cm increment under three slopes categories viz., <10, 10-33% and >33%. Three profiles opened, one for each slope category, from all five forest lands. Soil samples were processed and estimated soil organic carbon with standard procedure. Soil core sample was collected for bulk density estimation. Soil organic carbon stock (SOCS), kg m^{-3}, was estimated from per cent organic carbon, bulk density and depth of soil with the following procedure of *Grossman et al. (2001*). Tropical evergreen forest recorded the SOCS of 13.44 kg m^{-3} and the highest stock was recorded in <10% slope. The SOCS was 90 and 58% higher >33% slope and 11-33% slopes respectively. Teak forest recorded 11.32 kg m^{-3} of SOCS and the highest SOCS was recorded in <10% slope which was 49% higher than >33% slope. Reverse trend of teak forest was observed in deciduous forest with the SOCS of 9.08 kg m^{-3} and the highest SOCS was recorded in in >33% slope which was 184 % higher than <10% slope. Soil organic carbon stock in bamboo forest was 18.02 kg m^{-3} and the highest stock was recorded in <10% slope land which was 28% higher than the >33% slope. Bamboo forest with dense vegetation and thick density of root has conserved soil along with organic carbon therefore the SOCS was the highest among tropical forests. Lowest stock was found in dry deciduous forest where the vegetation is spares and more human activities in lower slope areas which caused high soil and organic carbon losses. The forest vegetation with higher biomass and land cover has supported the storage of more organic carbon. However, the bamboo forest with higher biomass, land cover and root cover has stored more carbon than other forests.

Keywords: *Hilly region, land cover; forest vegetation; soil organic carbon stock*

Effect of different soil and water conservation practices on water quality in the adopted village ponds of north - western Himalayas

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The water resources in the lower Shivalik region of Jammu are 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 rain fed spread over the span of 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 & 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 should be trapped in these ponds. The conservation modules which were adopted for improving the water quality of ponds are Digital Elevation Model (DEM) mapping of watershed area, bunding, contour bunding, promoting terrace farming to reduce soil loss, diversion of sewage water, constructing channels to divert rain water into ponds & promoting rain water harvesting. Various water physico-chemical & biological parameters were assessed using standard procedures before and after adopting conservation modules. 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 & 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 & 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 & local residents of village also played an important role as they will help in participatory approach for the conservation of these ponds.

Keywords: *Water Quality Index, Digital Elevation Model. Conservation modules, ponds*

Technology Enabled Sustainable Green Environment

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The need for sustainability in environment has numerous problems in terms of our understanding and it terms of applying this. The term "environmental sustainability" may be some different from common perception of the nature of human activity. Mostly this may incorporate 'technological sustainability'. Computer Networks, IoT enabled apparatus and Big data & Machine Learning applications can play a vital role in sustain environment. This paper describes about various hardware and software applications which are useful in environment sustainability. It also explores IT utility extends to human-centered environmental control, security, energy efficient and sustainable green environment.

Keywords: *Sustainable Green Environment, Technological Sustainability, Computer Networks, IoT enabled apparatus, Big data, Machine Learning*

Production of Agri-biochar from the pyrolysis of waste organic material and its utilization for acid soil management

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Soil acidity is one of the major constraints in crop production throughout the world. Approximately 95 per cent soils of North-Eastern Region (NER) of India are acidic, with nearly 65 per cent soils under strong acidity with pH less than 5.5. For managing soil acidity, liming is the conventional practice; however it may not be economical in the regions where it is expensive. Agri-biochar may be an alternative cheap and good organic source to overcome this problem. The NER produces huge quantity of crop residue/weed biomass which is traditionally burned to provide a fast way to clear the agricultural fields that causes loss of valuable biomass, nutrients and release of toxic gases including GHGs. There is an immense scope for converting millions of tonnes of crop residues/weed biomass into agri-biochar that can be utilized for managing soil acidity. There are many ways to produce agri-biochar but all of them involve heating biomass with little or no oxygen to drive off volatile gasses, leaving carbon behind. Pyrolysis is a process of the decomposition of biomass without combustion at controlled temperature. To optimize the dose of agri-biochar (B) in combination with vermicompost (V) and graded recommended doses of N, P, K fertilizers (F) for maximizing tomato (cv. Megha Tomato-2) productivity and improving soil acidity indices in NER, a field experiment was conducted during *rabi* season of 2017-18 at School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, CAU, Umiam (Barapani) involving sixteen treatments in RBD with three replications. The results indicated that plant height, number of fruits/plant, fruit size and fruit yield of tomato was superior with the application of B (4 t/ha) + RDF (100% NPK) + V (2.5 t/ha) and soil acidity indices also improved significantly over control plots.

Keywords: *North eastern region, agri-biochar, tomato productivity, soil acidity indices.*

Impact of direct seeded rice on economics of paddy crop in Raebareli district

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Production of conventional puddled transplanted rice is facing severe constraints because of water and labour scarcity and climatic changes. Direct-seeded rice (DSR) is a feasible alternative to conventional puddled transplanted rice with good potential to save water, reduce labour requirement, mitigate green-house gas (GHG) emission and adapt to climatic risks. The yields are comparable with transplanted rice if crop is properly managed. In recent years, efforts have been made in promoting the DSR technology by various organizations. Scientists are concentrating in developing suitable varieties and agronomic packages for promoting the DSR. However, the DSR suffers from some constraints particularly high weed infestation. The system has been proved cost-effective and farmers' friendly but require further improvement in technological approach to realize greater benefits. Keeping in view all these aspect during the year 2016-2109 a study concerned about an assessment of the resource and environmental constraints and cost analysis of transplanted rice (TPR) and direct seeded rice (DSR) is made in agri-economics context to suggest options for promotion of DSR in Raebareli District. Results indicated that net return was higher in DSR (Rs. 57075.00) as compared to TPR (Rs. 46120.00) and B:C ratio was found 2.38 in DSR while it was only 1.82 in TPR. Thus, net returns were 19.19 % higher in DSR than TPR method as cost of cultivation was 26.71% less in DSR. It was observed that farmers could save 72.88% labour cost and 33% irrigation water in DSR as compared to transplanted rice. The results showed that DSR method of paddy cultivation was more economically efficient compared to TPR system.

Keywords: *Direct Seeded Rice, Transplanted Rice, Promotion, Economics*

Water Management Under Changing Climate

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Life without water is unimaginable. Water is not only critical input for plants but it is also essential for human lives and other living creatures on the earth. Water is considered as one of the infinite resources on this earth but the availability of the fresh water out of total water present is just 2.5%. Out of this 68.9 % is ice and permanent snow cover, 29.9 % is ground water, 0.3 % is in the form of rivers and lakes and 0.9 % soil moisture. The total utilizable water remains constant over the period but due to increase in the population, economic activities and climatic change, it affects on the demand and supply, and thereby may render a location either excess or deficit. As per the Falkernmark water Stress index, a country or region will be under water stress condition when per capita annual water supplies drop below 1700 m^3. When the per capita availability ranges between 1700 to 1000 m^3 it is periodic or limited water shortage condition and when per capita is less than 1000 m^3 level the region faces water scarcity (Falkernmark.1989) Now for India, the average annual per capita water availability in the years 2001 and 2011 was assessed as 1816 cubic meters and 1545 cubic meters, respectively which may further reduce to 1486 cubic meters and 1367 cubic meters in the years 2021 and 2031, respectively. (Source: Ministry of Jal Shathi). With respect to agriculture due to climate change, Himalaya snow and ice which provide vast amount of water for agriculture in Asia are expected to decline to 20 % by 2030. By 2025, 1800 million people will be living in countries or region with absolute water scarcity and two-third of world population could be under stress condition. Out of total available fresh water, 70 % is used for Agriculture (irrigation), 22% for Industry and remaining 8 % for domestic use. This needs immediate attention and judicious use of water resource is the need of hour. Hence, to overcome, few strategic plans available to reduce the future water stress are high water efficient crops, increasing water use efficiency by minimizing conveyance and evaporation losses, promotion of solar voltaic pumping system for ground water pumping system for to reduce carbon emission, encouraging group tube well for efficient use of ground water resources, provisions for irrigation at critical growth stages especially during long dry spell, efficient use of rainfall by following rainfall forecast, expansion of micro-irrigation system in agriculture (especially in Sugarcane), substituting flood irrigation paddy cultivation by SRI/aerobic paddy, promotion of short duration oilseeds or pulses under assured ground water supply, groundwater recharge by following soil and water conservation measures, reuse of treated waste water, rejuvenation of traditional water bodies/tanks, intensive afforestation.

Keywords: *Climate change, Water management, water scarcity, Micro irrigation, treated waste water*

Yield of sugarcane varieties at Krishi Vigyan Kendra (ICAR-IIVR), Kushinagar U.P.

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Krishi Vigyan Kendra (ICAR-IIVR), Sargatia, Seorahi, Kushinagar assessed the comparative performance of different sugarcane varieties in district Kushinagar U.P. during the year 2015 to 2019. Under investigation varieties like Co 0238, CoS 08272 and CoSe 8452 have been taken. Results shows that planting of sugarcane in paired row in trenches variety Co 0238 gave higher yield i.e.725.35 q/ha. in comparison to rest other varieties. The yield of other varieties respectively is 610.55, and 610.45 as CoS 08272 and CoSe 8452. Sowing of sugarcane in paired row save seed, fertilizer, fuels, water and man power and increases the productivity of crop. The weight of per sugarcane average is maximum recorded in the variety Co 0238 i.e. 2.30 to 3.35 kg. The plant height, softness, nutrient use efficiency, water use efficiency and weight in per trolly of sugarcane average is maximum recorded in the variety Co 238.

Keywords: *Sugarcane, yield and varieties.*

Exploration of native lignocellulolytic actinobacteria and their evaluation as biodegrader of water hyacinth biomass

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The investigation was aimed to isolate and identify the native lignocellulose biodegrader actinobacteria for biological degradation of water hyacinth biomass and convert it into nutrient rich compost. Total 40 actinobacterial cultures were isolated from agricultural fields as well as dumping site and screened for cellulose degradation ability on carboxy methyl cellulose (CMC), three actinobacterial isolates were selected for further studies based on their highest activity on CMC. The solubilization index (SI) by actinobacterial cultures was ranged from 2.17 to 3.33. Based on morphological, cultural, biochemical and molecular characterization, selected efficient actinobacterial isolates M 2, M 10 and M 16 were found as Streptomyces sp. AAUBD M-2, *Streptomyces rochei* AAUBD M-10, and *Streptomyces chartreusis* AAUBD M-16, respectively. Sequencing of 16S rDNA was carried out and the sequences were submitted in NCBI gene bank (Accession No: MN581484; MN581673 & MN582992).

The cellulose and lignin degradation efficiency of selected isolate were preliminary examined for cellulose degradation ability by filter paper degradation assay and lignin degradation by decolorization of lignin by flask assay, all three isolates were found effective for lignin and cellulose degradation in their respective flasks assay. All filter paper was degraded between 9 to 15 DAI. The best result obtained from the pot study was in treatment T4 which consists of actinobacterial consortium and cow dung. Treatment showed higher degradation with all desired characters like color change of degraded product, earthy sweet odour, compaction of mass, particle size reduction at 45 DAI with highest moisture content (48%), lower C:N ratio (14.2), with better nutrient content like nitrogen (1.90%), phosphorus (0.95%), potash (1.72%), organic carbon (27.0%).

Keywords: *Biodegradation, Actinobacteria, Water hyacinth, lignocellulolytic, compost*

Effect of Different Sowing Environment and Varieties on Production Potential of Maize Under Central Plain Zone of Uttar Pradesh

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A field experiment entitled "Effect of Different Sowing Environment and Varieties on Production Potential of Maize Under *Central Plain Zone* of Uttar Pradesh" was under taken at Students' Instructional Farm of C.S. Azad University of Agriculture & technology, Kanpur to study the effect of different sowing environment and varieties on production potential of maize Under C*entral Plain Zone* of Uttar Pradesh. The experiment was tested with Split plot design. Three date of sowing i.e. 19th June, 29th June and 9th July, 2020 were executed in main plot and three maize varieties Azad Hybrid-1, Azad Hybrid-2 and DKC-7074 were sown in sub plot. The crop was sown with 60x20 Cm row spacing. The highest maize seed yield (61.6 q/ha) was obtained under 19th June sown crop as compared to 10 days further delayed sowing. This might be due to maximum temperature (36.4^{0}C) favoured higher germination in early sown (19th June) crop. The higher maximum and minimum temperature and Heat Unit accumulated during emergence, knee high, 50% tasseling, Dough and Maturity favoured higher yield attributing characters and yield in early sown crop. Although all three varieties showed comparable response but Azad Hybrid-2 accumulated highest yield (59.7 q/ha.) and Heat Use Efficiency (10.6 g/m^{2}/^{0}C day) followed by Azad Hybrid-1 and DKC-7074.

Keywords: *maize, sowing environment, production potential*

Effect of mole drainage system on Growth Characters and Yield of Soybean in waterlogged Vertisols in Malwa region of Madhya Pradesh

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Mole is a Climate smart drainage approaches for enhancing soybean productivity in water logged vertisols in Malwa region of Madhya Pradesh A field experiments was conducted during kharif season 2015 and 2016 to assess growth parameters and economics of mole drainage system in vertisols of Shajapur district of Madhya Pradesh. Mole drains can be formed in vertisols at when the average soil moisture content is between 22.7 - 26 % and average clay content is 52.31% at moling depth. Field capacity of mole plough for mole drains formation recorded highest under S_4D_1 (mole drains at the spacing of 8 m on the depth of 0.4 m) and lowest under S_1D_3 (mole drains at the spacing of 4 m on the depth of 0.6 m).Mole drain system was found better in terms of growth parameters; yield attributes and economics parameters comparison with the control for soybean crop in kharif. The net return is the best index of profitability of crop production and higher net return 29870 per ha were recorded for soybean crop y under mole drain with of spacing of 2 m at the depth 0.4 m whereas, the lower net return Rs 20608 per ha under control (No mole drain system). From the study, it can be concluded that the mole drains are best option for the water logged vertisols and it is the most appropriate, profitable and productive practice in kharif

Keywords: *Drain spacing, Drain depth, Mole drains, Soybean, Vertisols.*

Effect of pink pigmented facultative methylotrophs (PPFM) on yield attributes and yield of rice (*Oryza sativa* L.)

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A field experiment was conducted to assess the effect of PPFM on the growth of aerobic rice, at Integrated Farming System Research Station, Karamana, Thiruvananthapuram, Kerala, during summer, 2019 -2020 with the medium duration rice variety MO16 (Uma). The experiment was laid out in factorial randomised block design with [(5 x 2) + 2] treatments replicated thrice. The treatments comprised of five promising isolates of PPFM (P) obtained from the Department of Agricultural Microbiology, College of Agriculture, Vellayani, two methods of application (M) compared against two controls (C). Yield attributes and yield of rice exhibited significant variation in response to PPFM treatments. Among the five PPFM isolates tested, treatment with PPFM 38 recorded significantly higher productive tiller count (423.00), grain weight per panicle (3.01 g), filled grains per panicle (111.33) and thousand grain weight (24.12 g) and significantly lower sterility percentage (14.68%), grain yield (4.43 t ha^{-1}), straw yield (5.31 t ha^{-1}) and harvest index. Methods of application, seed treatment + foliar application at 30 and 50 DAS showed significantly higher number of productive tillers per square metre, grain weight per panicle, grain yield and straw yield. No significant variation in the number of filled grains per panicle, sterility percentage, thousand grain weight and harvest index method of application of PPFM. Seed treatment (1%) followed by foliar application (2%) of PPFM 38 at 30 and 50 DAS (p_5m_2) resulted in higher number of productive tillers per square metre, grain weight per panicle, grain yield and straw yield of rice. However, number of filled grains per panicle, thousand grain weight and harvest index were higher with p_5m_1 (PPFM 38 as seed treatment).Between the two controls, yield attributes and yield were significantly superior in KAU POP (c_1) than KAU POP + water spray (c_2).

Keywords: *Pink pigmented facultative methylotroph*

Soil erosion studies under simulated rainfall conditions in a lateritic terrain

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The study was carried out in the lateritic terrain of KCAET campus, Tavanur, Malappuram District. This study was aimed at developing a rainfall simulator and studying the performance of the developed rainfall simulator, the effect of rainfall on soil loss, the effect of rainfall on runoff and developing a soil erosion model. A rainfall simulator was fabricated to study the erosion processes. *Rainbird* 12/15/18 Van Pop up sprinkler heads were used as the drop formers. The simulator evaluated for its performance. The soil was reddish brown and belonged to the textural class of sandy loam. It belonged to the *Naduvattom* series. The *experimental* set up consisted of three units viz., the runoff plot, the rainfall simulator and the runoff-sediment collection unit. Twelve runoff plots with twelve different slopes of 1.5, 2.0, 2.6, 3.0, 3.2, 4.0, 5.0, 6.0, 9.0, 10, 12 and 13 per cent in different locations, each plot with a size of 2 x 1.5 m were prepared. The fabricated rainfall simulator could produce rainfall intensities varying from 8.16 to 8.80 cm/h. The uniformity of rainfall varied from 89.01 to 92.70 per cent and the average drop size varied from 1.5 to 2.8 mm. A relationship between supply pressure and intensity of rainfall as well as intensity and uniformity of rainfall was developed. Studies were conducted on soil loss and runoff at different land slopes under simulated rainfall conditions. The soil loss and runoff was found to increase with increase in rainfall intensity and land slopes and there were no much variations on runoff and soil loss at 6 to 10 per cent land slopes.

A linear multiple regression analysis and 3D surface plot analysis was used to incorporate slope and rainfall intensities into a single prediction equation of soil loss and runoff using SPSS software and MATLAB package.

The linear equations developed by the regression analysis are as follows:

$$Q = 38.945\ I - 11.606\ S - 126.391 \qquad (R^2 = 0.649)$$

$$E = 124.356\ I - 0.807\ S - 951.420 \qquad (R^2 = 0.307)$$

The quadratic equations developed by the 3D surface plot analysis are as follows:

$$Q = 130.8 - 28.72\ S + 48.12\ I + 2.11\ S^2 - 1.544\ S\ I$$

$$E = -647.4 - 49.26\ I + 86.94\ S - 0.3206\ I^2 + 6.296\ S\ I$$

As the variants explained were satisfactory enough to explain the runoff and soil loss, it may be concluded that the causative factors namely slope and intensity are bearing directive impact on soil erosion.

A canonical analysis was worked out to determine the effect on runoff and soil loss by the vector of parameters using slope and intensity. Canonical R was computed and the same was 0.82034 and it is significant at 1 per cent level. Hence it may be concluded that the vector of process including slope and intensity as parameters together navigates the ultimate impact namely runoff and soil loss.

Keywords: *Rainfall simulators, Rainfall intensity, Runoff, Soil loss*

Growth and yield of rice (*Oryza sativa* L.) varieties as influenced by nutrient management under irrigated-aerobic condition

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A field investigation was carried out during *kharif* 2019 at Agricultural Research farm, Binjhagiri, Chhatabar, Faculty of Agricultural Sciences, IAS, SOADU, Bhubaneswar to study growth and yield of rice(*Oryza sativa* L.) varieties as influenced by nutrient management under irrigated-aerobic condition. The experiment was laid out in split plot design with three replications comprising fifteen treatment combinations. Treatments consisted of three varieties (V_I- CR Dhan-205, V_2- Naveen, V_3- Nirmal-150) in main plot and five practices of nutrient management (F_I - Control, F_2 – 40:20:20 $N:P_2O_5:K_20$ kg/ha, F_3 -80:40:40 $N:P_2O_5:K_2O$ kg/ha , F_4 - 120:60:60 $N:P_2O_5:K_2O$ kg/ha, F_5- 160:80:80 $N:P_2O_5:K_2O$ kg/ha) in subplot. Study revealed that among the varieties, CR Dhan 205, an aerobic rice variety, performed well and produced significantly the highest yield of grain (4.01 t ha^{-1}) and straw (5.3 t ha^{-1}) . The increase in grain yield was associated with significantly higher Number of filled grain/panicle (107.7), Ear bearing tiller per m^2(288.6) , and test weight(23g) . Among the nutrient management practices, F_4 -120:60:60 $N:P_2O_5:K_2O$ kg/ha recorded highest yield of grain (4.36 t ha^{-1}) & straw (5.86 t ha^{-1}) and it was at par with F_3 -80:40:40 $N:P_2O_5:K_2O$ kg/ha. The variety Naveen closely followed with CR Dhan 205 and with respect to fertility level.

***Keywords*:** *Nutrient management practices, aerobic condition, rice varieties, grain yield*

Impact of Climate Resilient Farming Practices on Food Security during Lockdown by COVID-19 Pandemic in Odisha

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The COVID-19 pandemic hits harder to the farming community and made food insecurity worldwide. Small and marginal farmers were most affected due to subsequent lockdown and unavailability farm inputs. The lockdown came into force when there was peak rabi season in India and crops like wheat, gram, lentil, mustard, etc. (including paddy in irrigated tracts) are at the harvesting stage or almost reaching maturity. This is also the time when the farm harvests reach to the *mandis* (market yards) for assured procurement operations by designated government agencies. Moreover, any severe disruption to the supply of perishable fruits and vegetables, dairy products, fish, etc. having mobilized to meet the increasing demand from a bulging middle class as well as urban and rural consumers, may create irreparable damage to all actors in the supply chain. The migration of workers from a few parts to their native places has also triggered panic buttons, as they are crucial for both harvesting operations and post-harvest handling of produce in storage and marketing centres. Telephonic survey was conducted to understand the coping mechanism and challenges during consecutive lockdown between climate smart agriculture (CSA) and Non-CSA practitioners (n=100). Results suggested that non-CSA farmers are more vulnerable and dependent on bartering for several goods. CSA farmers relay on their integrated farming system and rarely visit the local market. Bartering (goods) and community approach (harvesting and post-harvest management) were promising and played a crucial role to cope up during the lockdown crisis. Nutritional security in terms of diverse and nutrient rich diet CSA farmers had advantage over non-CSA farmers. Knowledge and awareness of ICT tool also back supporting CSA farmers to know the govt. schemes and plans about the inputs and advisory to do the agricultural activities. In nutshell, climate resilient farming practices averse the risk to some extent and paving ways to cope up with COVID-19 pandemic crisis.

Keywords: *Bartering, social distancing, community approach, coping mechanism, climate smart agriculture*

Tropical tuber crops: Potential future crops under the changing climatic scenario

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Climate change has far reaching implications for global food security. It has substantial impacts on agricultural production through effects on soil fertility, carbon sequestration, microbial activity as well as on plant growth and productivity. Tuber crops are the third most important food crops of man after cereals and grain legumes. It is estimated that tuber crops provide about 6 per cent of the world's dietary energy, apart from being good sources of β-carotene, anti-oxidants, dietary fibre and minerals. They have higher biological efficiency, can tolerate drought and shade, withstand flooding and salinity to some extent, are adapted to marginal environments, low input situations and adverse soil and climatic conditions. Hence, these crops are designated as "climate resilient" or "future crops". The climate change would reduce food production in most of the lowland tropical and subtropical farm lands, but it may increase it in the high lands and the traditional very cold temperature areas of the world. These will have a profoundly destabilizing effect on global food production. Root and tuber crops, are expected to show a large response to rising atmospheric CO_2 due to its large below ground sinks for carbon. Tuber crops are capable to utilize available resources more efficiently especially in partial sunlight and residual moisture. Great flexibility in planting and harvesting are additional characters of these crops which are suitable to include in any farming systems. Wider adoptability and greater flexibility in planting and harvesting of tuber crops makes them fit into any cropping/farming systems. Partial shade tolerance of yams and aroids was found highly suitable to intercrop in grown up orchards and plantation crops. High dry matter production potential/ unit area/ unit time coupled with cheap source of energy encourages farmers to use tuber crops in livestock feeding. Tuber crops products can be used in fresh form or dried form or ensiled form in animal feeding, which is the uniqueness of tuber crops. In small holder farming systems growing tuber crops along with seasonal crops, feeding green tops and excess tubers either fresh or processed form to animals decreases the purchased inputs and increase the farm net income. In the changing climate, tuber crops are indispensable in small holder farming systems along with cereals, livestock and fisheries. Thus, food and nutritional security can be achieved through tuber crops based sustainable farming systems.

Keywords: *Tropical tuber crops, Carbon sequestration, Climate resilient*

Climate Smart Agriculture: Key to Sustainable Production and Food Security

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Climate change due to human activity, which alters general composition of global atmosphere and natural climate over a period of time, is arising as one of the major threats facing our planet. The negative impacts of climate change are flood, heat waves, drought and other extreme-weather events, as well as creating an arrival of new pests and diseases. This in turn adversely affects the agricultural productivity, food security, sustainability and hence the economy of a country. Also, agriculture itself makes a major contributes to climate change by emitting green house gases. In an agrarian country like India, climate change is an additional burden as agriculture depends mostly on local weather parameters like rainfall, temperature, solar radiation, humidity, etc in long term. Hence, to improve agricultural production under changing climatic situations (like elevating CO_2 level, temperature, sea level and unforeseen weather conditions), the existing agricultural practices in our country are required to be planned, managed and implemented in a sustainable manner. So climate smart agriculture (CSA) can help in mitigation and management of climate change scenario. CSA is an approach for evolving agricultural strategies under climate change to sustainable agricultural development. Climate smart agriculture aids in improving the agricultural production and food security in an ecofriendly way by diminishing the risk on natural resources. The selection of suitable high yielding crops, adoption of integrated farming, intercropping, proper nutrient and residue management, resource conservation technologies (water- saving technologies and water- harvesting structures), agro-forestry, weather forecasting, and crop insurance are some of the climate resilient agricultural strategies to increase the productivity. This article aims to gain insights to climate change, its adverse effect on agriculture and identification of climate smart agricultural strategies. Adoption of suitable climate smart approaches which integrates the traditional and innovative technologies will enhance the resilience for farming community and thus ensure viable livelihood.

Keywords: *Climate change, Sustainable production, Climate Smart Agriculture (CSA), CSA strategies, Water saving approaches*

Artificial glaciers: A sustainable technique in conserving water crises in cold-arid region of Ladakh

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Ladakh is considered as one of the coldest inhabiting regions situated at 2700-4,000 m above sea level with annual rainfall less than 100 mm in the rain shadow of the northern part of Indian Himalaya. The local inhabitants depend most of its agriculture and domestic activities on glacial streams throughout the year. However, the challenges of sustainable water conservation are magnified by the sudden change in global climate scenario and local people are experiencing shortage of water due to irregular freeze and thaw cycle of glaciers. Thus, different techniques have been adopted by locals in overcoming the regular demands of water in cold arid region of Ladakh. Earlier attempts like, traditional recharge structure were locally developed by digging deep into earth called as Zing which enables water storage for shorter periods. However, with increase in its demand with water scarcity, glacial-dependent artificial glaciers and ice stupas were invented in recent times. Artificial glaciers are method of freezing and storing the water in large horizontal areas that keeps flowing and wasting away down the streams and into the rivers throughout the winter. Ice Stupa is a prototype of artificial glacier which involves its structure in vertical position with minimum ground surface area, used for storing winter water in the form of conical shaped ice structures. The construction of horizontal artificial glaciers channels slow down its stream at each checks near a shadow area of a mountain protecting from direct sunlight while the vertical ice stupas involves siphoning through a pipes from higher to lower heights which mainly depends upon the hydraulic head. The concept of slowing down the water flow in horizontal artificial glaciers is to release heat so that fast moving water can't be freeze momentarily whereas in Ice stupas, the sprinkling of water droplets from the hydraulic head freezes the water instantly when comes in contact of sub-zero temperature. With the onset of summer in cold arid region like Ladakh, locals are able to utilizes the fast melting artificial glaciers for agricultural and domestic purposes reducing the critical gap of water availability from natural glaciers. In addition, this technique of water resource conservation are inexpensive, eco-friendly and required no technological experiences. Therefore, these artificial glaciers increase the overall ground-water recharge, reducing complete dependency on melting of glaciers melting and providing a sustainable source of water for agriculture. The aim of this summery is to bring the concept of artificial glaciers which could be adopted to other trans-himalayan region and beyond.

Keywords: *artificial glaciers, ice stupa, zing, water conservation*

Precision Agriculture: Key to Mitigate the Adverse Effect of Climate Change

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Nowadays, population explosion is one of the great challenges faced by the different sectors, and agriculture is one of them, which is significantly affected. There is a great pressure on the farmers and persons allied to agriculture to boost the production by existing available inputs to feed the soaring population. To meet this challenging demand, precision agriculture emerged as robust approach to solve this problem as well as mitigating the adverse effect of climate change and global warming. Precision agriculture is simply defined as to getting the maximum production by minimizing the input resources of it i.e site specific use of the inputs. To understand the precision agriculture and various aspect of it, a review was done covering different approaches and methods related to same. In present study, it is showed that approaches of precision agriculture can be divided in two parts soil and water management. It can be further classified as nutrient management, weed management and water management. These components cover every input of agriculture to conserve the numerous vital natural resources. There is also subdivision of these managements such as nutrient management can be soil amendments and foliar application or bio manure, increase of weed management tillage practices and use of different pesticides and in case of water, different water conservation technologies. This brief review can help researchers as well as farmers to understand the broad view of the precision agriculture.

Keywords: *Precision agriculture, agriculture management, nutrients management and water management*

Mirid Bug *Nesidiocoris tenuis* (Hemiptera: Miridae) an emerging pest on Sesamum

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Sesamum (*Sesamum indicum* L.) is also called as 'Queen of Oilseed crops' one of most important oilseed crop cultivated over 5000 years by human beings. It belongs to family Pedaliaceae. Sesamum is called by different names in different localities like Til (Hindi), Tal (Gujrati), Tili (Panjabi), Nuvvulu (Telugu), Elu (Tamil) and other names like sesame, simsim, benised, gingelly, gergelim, etc. India ranks first in production (14.83%) in 8.12 lakh ha area with productivity of 413 kg ha^{-1} of sesamum during 2017-18. It is mainly grown on Rajasthan, Maharashtra, Gujarat, Andhra Pradesh, Karnataka, West Bengal, Orissa, and Panjab. The crop is infested by number of pests which reduce its yield both in the form of quality and quantity. Among various insect pests infesting sesame, *Acherontia styx, Antigastra catalaunalis, Cystopteris tenuis* and *Spilarctia oblique* were responsible for the low productivity of sesame. As we noticed sucking pest that is devasting sesamum plants is a Mirid bug or Tomato Bug, *Nesidiocoris tenuis* (Hemiptera: Miridae). The sesamum crop variety RT-351 was raised during *Kharif*, 2019 at Experimental Farm, College of Agriculture, Bikaner, Rajasthan, India. The mirid bug *Nesidiocoris tenuis* was noticed at initial stage of the crop on the leaves of the plant. The population of mirid bug was counted manually by visual observations. The mirid bugs, *Nesidiocoris tenuis* are yellowish green colored insect about 5-6 mm in length with black spots on their hind wings and large bulging dark eyes. The nymphs are also green about 4 mm long. Adults and nymphs are colonize in large number on the underside of leaves and on stems. Adults and nymphs pierce the tender leaves and shoots and suck the cell sap. The maximum incidence was observed on 20th August, 2019 and the minimum on end of September, 2019. The average number of insects ranged between 4 to 6 adults and 4 nymphs per leaf. The population of mirid bug showed declining pattern as crop reaches maturity. At the time of harvesting the insect was disappear.

ECG studies on gastroenteritis and urinary tract diseases affected dogs

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The present study was conducted to investigate characteristics of electrocardiography in gastroenteritis (GE) and urinary tract diseases (UTD) in dogs. The positive cases of GE (Group B) and UTD (Group C) affected dogs were screened for ECG and haemato-biochemical parameters as per the standard procedure and the outcome was compared and correlated statistically with healthy dogs (Group A). A decreased in amplitude of P wave, T wave and QRS complex were observed in both the affected groups (Gr. B & C) as compared to Group A. Additionally, a significant ($P < 0.05$) decreased in Hb, PCV, TEC, MCHC and TP and increased in AST and ALT were also noted in Group B whereas decreased Hb and TEC and increased in BUN, Creatinine and ALP were observed in Group C. There was significant ($P< 0.05$) positive and negative correlations between Electrocardiogram and haemato-biochemical parameters were observed in both the affected groups. The study revealed that ECG and haemato-biochemical parameters had a significant role in extra-cardiac diseases i.e. gastroenteritis as well as urinary tract diseases in dogs.

Keywords: *ECG, extra-cardiac diseases, gastroenteritis, urinary tract diseases, dogs.*

Impact of potassium and K-biofertilizer on economics of potato (*Solanum tuberosum* L.)

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A field experiment was conducted during the winter (Rabi) season of 2017-18 to find out the suitable effect of different agronomic manipulations based on potassium and K-biofertilizer to maximize economic potential of potato. Potassium management practices were Control (K_1), 100% recommended dose of potassium (RDP) through inorganic fertilizer (K_2), 75% recommended dose of K through inorganic fertilizers + K-biofertilizer (K_3), 50% recommended dose of K through inorganic fertilizers + K-biofertilizer (K_3) and K-biofertilizer (K_5) only were tested on 'Lady Rosetta' potato (Solanum tuberosum L) at Department of agriculture, Khalsa College Amritsar. Economic analysis of integrated nutrient management of potato crop was done using total input cost, gross returns, and net income concepts in USD dollar per ha for the year 2017-18. Both 100% RDF and 75% recommended dose of potassium + K-biofertilizer is recommended for higher economic returns.

Keywords: *Potassium, K-biofertilizer, potato and economic etc.*

Interaction effect of VAM with different amendments on increasing phosphorus uptake

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Phosphorus, a essential element for all living organisms but it is often the most *limiting nutrient in soil*-plant systems. In order to increase the phosphorus content in plants and its uptake efficiency in alkaline soil, the following study was undertaken. The experiment was carried out in a factorial completely randomized block design with five treatment combinations viz., Control (no P), P alone, P with FYM, EFYM and P with Humic acid and all the five treatments were tried with and without VAM and the experiment was replicated four times. The phosphorus concentration in soil and plant samples were analysed. The available phosphorus status in soil showed a decreasing trend along the growth stages of maize but the application of P with FYM and as EFYM recorded significantly higher available P in all the stages. The plant P concentration also showed the decreasing trend along the crop growth stages and recorded the highest concentration in P with FYM and VAM treatment. The grain P uptake and stover uptake was also found to be higher in the application of P and FYM with VAM. The combined application of inorganic minerals along with organics and bioinoculants can enhance the soil quality and health for the sustainable crop production.

Keywords: *Phosphorus, VAM, FYM, P uptake.*

Organic Farming in Horticultural Crops for Sustainable Productivity

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India is the fruit and vegetable basket of the world. It grows a variety of fruits and vegetables and has huge production of both fruits and vegetables. India is the second largest producer of both fruits and vegetables in the world after China Largest producer of ginger and okra amongst vegetables & ranks second in production of potatoes, onions, cauliflowers, brinjal, cabbages, etc. Amongst fruits, the country ranks first in production of Bananas (25.7%), Papayas (43.6%) and Mangoes (40.4%).Organic farming, which is a set of farming methods, and also a grassroots peasant movement, has spread to various states in India. It has attained wide success in southern India, especially the southern Indian state of Karnataka where it first evolved. A rough estimation for just Karnataka puts the figure there at around 100,000 farmer's families, health comes foremost in our lives but today the issue regarding general health of humans is far more than terrible. Our daily lifestyle has worked as a fuel for the fire that is burning our body with diseases we could not possibly imagine a century ago. But far from that, the food we intake to fuel our lives has become a slow poison. Latest reports from WHO points that more than 50% of eatables have chemicals which are carcinogenic in nature and fruits and vegetable played important role in human balanced diet and due to improper storage, and use of chemicals for artificial ripening leads too many problems in human health, cancer like diseases are increasing day by day and to counteract these problems the only & only solution is grow fruits and vegetables by means of organically, by using natural inputs for quality and human nutrition as well as sustainable productivity.

Keywords: *Fruit, Vegetables, Organic Farming, Sustainable Productivity*

A model for sustainable agriculture through organic farming in post Covid-19 scenario

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COVID-19 has imposed a powerful negative impact on agricultural scenario in all over the world. Scientists predicted significant rise in hunger, malnutrition and declined production rate as the consequence of severe job loss, economic fall and drop in family income due to COVID-19 scenario. Agricultural practices with injudicious us of chemical inputs already put enough stress on ecosystem through a vast array of antagonistic reactions resulting upsurge of weeds and pests. The easy availability of synthetic chemicals that strengthens the decades-long habit of applying the inputs in agricultural fields, the entire food web itself has become contaminated with harmful residues of fertilizers or pesticides as well as the loss of production also. Toxic chemicals and its metabolites permeate into the food pyramid not only through primary levels at grain or vegetable production, but also through secondary levels at livestock and fish farming during the time of preventive and curative medications as an easy gateway. The high dependency on the readymade inorganic food sources as the feed materials, rampant use of synthetic growth promoters for the live stocks or fisheries may increase the production, but alarmingly weakening the quality of the product with contaminated food chain that augments the threats of diverse health disorders. At this complex backdrop, an integrated farming approach is needed that will in one hand, foster the natural food production system with intra-dependency at both primary and secondary levels using the tools of organic farming and on the other hand will increase the farm family income. In doing so, a convergent model must be drawn where migrant labors can be encouraged and engaged in the integrated livestock farming system. Various on-going schemes like NREGA or ATMA may be used for establishment of animal sheds at the behest of local administrative authority. Large quanta of wastes from the livestock would stimulate production of nutrient enriched compost, bio-fertilizers and bio-pesticides by the migrant labors that will not be the burden of our society but wealth. Krishi Vigyan Kendra (KVK) may spearhead the whole activity at the district levels by imparting necessary training and demonstrations to beneficiaries. Thus a self-sustaining model involving production of organic inputs and its local marketing could be drawn in the canvas of second green revolution through organic farming that will not only revitalize our agriculture and ecosystem but also empower the migrant labors in post COVID-19 situation.

Keywords: *Covid-19, production rate, economic fall, integrated livestock farming system NREGA & ATMA.*

Plant growth promoting activity of rhizobacteria

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The wide use of chemical fertilizers contributes largely to the decline of the environment which results the loss of soil fertility due to imbalanced use of fertilizers that has adversely impacted agricultural soil and crop productivity. Hence, alternative sustainable agricultural practices and biotechnological approaches to increase crop productivity, improve soil health and conserve biodiversity are in great demand. Therefore, use of plant growth promoting bacteria (PGPB) as a biofertilizer and biocontrol is a safe and sustainable method for agriculture. Plant growth- promoting rhizobacteria (PGPR) are free living bacteria present in the rhizosphere of the plant, enhanced the growth of the plant either directly or indirectly. The indirect promotion of plant growth occurs when PGPR lessen or prevent the deleterious effect of plant pathogens on plants. The direct mechanisms involve nitrogen fixation, phosphorus solubilization, Hydrogen cyanide, production of phytohormones such as auxins, cytokinins and gibberellins, and lowering of ethylene concentration.

Keywords: *PGPR, Biofertilizer, PSB, Phytohormones*

Technological Intervention (Pruning) for sustainable productivity of Nectarine cv Snow

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Now a days, for obtaining high quality fruits in the market, numerous horticultural techniques such as pruning and fruit thinning are. accomplished with the aim of improving the fruit size, better colour, higher sugar concentration etc. However, nectarines have a habit to produce large numbers of flowers and if the environmental conditions are conducive, may set excessively large number of fruits per tree and thereby, reduce the possibility of getting commercial fruit size with quality fruit at harvest. To avoid over cropping, the number of fruits per tree must be regulated, therefore, flower and fruit thinning are essential commercial practices to optimize fruit size, improve fruit colour, shape and quality and promote return bloom besides maintaining tree growth and structure Pruning being an important horticultural operation maximizes economic yield and produces excellent quality fruits. Pruning not only restores balance between shoot and root system but also maintains growth and vigour of shoots by allowing only fewer growing points to grow vigorously and thus regulate the crop. Performance of nectarine trees depends heavily on the proper pruning following annually. So different intensities of pruning on nectarine (*Prunus persica* (L.) Batsch var. *nucipersica*)" was ca During this investigation the effects of three different thinning techniques were studied on nectarine.The results of the experiment one revealed that heading back of shoots by 2/3rd of their length coupled with 20% of thinning out of shoots resulted in higher growth, floral and fruit quality attributes of nectarine. However, maximum fruit yield was recorded under control (20.37 and 18.43 kg/plant). The experiment was carried out at fruit research farm SKUAST-Kashmir Shalimar during the years 2016 and 2017. On the basis of results obtained in the present investigation, it may be inferred that nectarine trees heading back to 2/3rd of their length followed by 20% thinning out resulted in higher plant growth and better fruit quality fruits.

Keywords: *Nectartine, quality, productivity, Pruning, Snow queen*

Water testing and Quality of irrigation water

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Krishi Vigyan Kendra (ICAR-IIVR), Sargatia, Seorahi, Kushinagar assessed the quality of water taken from different villages and in rainy seasons in different days from 2016 to 2020. Soil reaction (pH) is normal from 7.3 to 7.9 and EC from 80 to 850 microsiemens per meter. I have collected hail in different years EC of hail is 75.00 microsiemens per meter and soil reaction is normal at 28.50 degree C. It can be concluded that the water of Kushinagar is excellent for sugarcane cultivation.

Keywords: *water testing, irrigation water, sugarcane*

Impact of conjoint strategy of nickel and zinc application on soil nutrient status and microbial functions under low nickel soil

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Nickel (Ni) is a costly input for crop production, therefore, judicious application of Ni, assumes to be relevant to addressing the Ni deficiency most economically and effectively. Zinc (Zn) is important for increasing the yield and nutritional value of crop production. Thus, the present pot experiment was undertaken to evaluate the effect of combined application of Ni and Zn application on soil nutrient status, microbial activity and biomass under low nickel soil (0.13 mg Ni kg^{-1}) of Sikhar block in Mirzapur district. The treatments consisted of control, recommended dose of fertilizer (RDF) and RDF along with combinations of four levels of Ni (i.e., 2.5, 5.0, 10, and 20 mg kg^{-1}) and three levels of Zn (i.e., 2.5, 5.0, and 10 mg kg^{-1}). The experiment was conducted in the 'kharif' season for two consecutive years 2018 and 2019 under completely randomized design (CRD) and replicated thrice by taking soybean as test crop. Conjoint application of RDF + Ni at 20 mg kg^{-1} + Zn at 10 mg kg^{-1} documented the highest available nitrogen (N) content in the post-harvest soil (PHS). The maximum DTPA extractable Zn content was recorded in RDF + Ni at 2.5 mg kg^{-1} + Zn at 10 mg kg^{-1}, whereas plant-available Ni in RDF + Ni at 20 mg kg^{-1} + Zn at 2.5 mg kg^{-1}. Application of RDF + Ni at 2.5 mg kg^{-1} + Zn at 2.5 mg kg^{-1} recorded the highest bio-available copper (Cu), iron (Fe), and manganese (Mn) content in PHS. The soil urease activity noted the maximum value in RDF + Ni at 20 mg kg^{-1} + Zn at 10 mg kg^{-1}, however, dehydrogenases, fluorescein diacetate, acid and alkali phospho-monoesterase activity were found maximum in RDF + Ni at 5 mg kg^{-1} + Zn at 10 mg kg^{-1}. Furthermore, the highest microbial biomass carbon and nitrogen was detected in RDF + Ni at 5 mg kg^{-1} + Zn at 10 mg kg^{-1}. The experimental data revealed that a higher dose of Ni application significantly reduces the microbial activity and biomass in PHS. It is therefore recommended that RDF + Ni at 5 mg kg^{-1} + Zn at 10 mg kg^{-1} has been applied to resolve the challenge of Ni deficiency in crop production.

Keywords: *enzymatic activity, microbial biomass, nickel, nutrient status, zinc*

Antimicrobial activity of phytoextracts of medicinal plants against plant pathogens

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The medicinal plants are rich source of natural chemicals as they possess a diverse range of secondary metabolities that are used for producing new antibiotics and different types of medicines which protect the human as well as plants against various diseases. The extracts of many higher plants have been reported to exhibit antibacterial, antifungal and insecticidal properties under laboratory trails. Plant diseases, caused by bacteria, fungi, virus and insect, reduce the productivity, yield and leading to huge loss. Among the different causal organisms, Fungi caused the greatest impact to plants with regard to diseases and crop production losses. The phytopathogenic fungi are generally managed by fungicides that are hazardous to environment as well as human health therefore, there is a need of new antibiotics and chemotherapeutic agents that are highly effective, possess low toxicity, and have a minor environmental impact and the use of plant extracts to control various phytopathogens came into existence as the plant extracts are safe, cheap, ecofriendly and produce various secondary metabolites which perform defensive role in plants. In the present investigation, the methanol and aqueous extracts of leaves as well as rhizome of three different medicinal plants viz. *Azadirachta indica*, *Lantana camara* and *Curcuma longa* were used against five fungal phytopathogens viz. *Curvularia lunata*, *Bipolaris specifera*, *Rhizoctonia solani*, *Macrophomina phaseolina and Alternaria alternata* by agar well diffusion method. Methanolic extracts of plant parts showed maximum antifungal activity against the phytopathogens than the aqueous extract. *Curcuma longa* rhizome extract showed antifungal activity against all the plant pathogens and maximum zone of inhibition was showed at conc. 200µl/ml against *Rhizoctonia solani*, *Bipolaris specifera, Curvularia lunata* and *Macrophomina phaseolina* (11mm, 7.66mm, 8mm and 7mm respectively), followed by leaf extract of *Curcuma longa* and *Azadirachta indica*. The minimum activity was showed by *Lantana camara.*

Keywords: *Medicinal plants, sequential extraction, antifungal activity, agar-well diffusion*

Effect of varying fertilizer doses and Soil Test Crop Response based Integrated Plant Nutrient System on quality and yield of Bhendi

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The advent of green revolution triggered the importance of inorganic fertilizers in increasing productivity of crops. It has been realized in the recent times that sustainability of agriculture mainly depends upon soil health and quality. Indiscriminate use of fertilizers without soil testing results in deterioration of soil health. The long-term food security requires a balance between increasing crop production, maintaining soil health and environmental sustainability. Considering the importance of the enhanced productivity in terms of soil health, it becomes necessary to relook the fertilizer recommendations made earlier. In Soil Test Crop Response (STCR) based Integrated Plant Nutrient System (IPNS) technology, the fertilizer doses are tailored to the requirements of specific yield levels of crop taking into account the nutrient requirement of the crop, the contribution of nutrients from soil, fertilizers and organic manures. A field experiment was carried out in Bahour soil series of Puducherry to study the quality and yield of bhendi in response to STCR based manure and fertilizer application. The experiment was carried out with ten treatments *viz.*, farmer's practice, FYM alone @ 12.5 t ha^{-1}, blanket recommendation, STCR-NPK alone @ 160, 170 and 180 q ha^{-1} and STCR-IPNS @ 160, 170 and 180 q ha^{-1} and control with three replications. The plant and fruit samples were drawn at 5^{th}, 12^{th} and 19^{th}stages of pickings and analyzed for quality parameters. The final fruit yield was also recorded. The results shown that the application of STCR + IPNS – 180 q ha^{-1} treatment could favourably improve quality parameters Such as mucilage (4.54%), protein (1.84%) and starch (4.95%) content and yield (17.95 t ha^{-1}) of Bhendi. When fertilizers are applied based on the STCR equations there is neither excess nor deficient levels of fertilizer doses. There will be balanced supply of nutrients, increased nutrient use efficiency and crop productivity. The STCR-IPNS technology ensures not only sustainable crop production but also economic use of costly fertilizer inputs. STCR-IPNS packages useful to recycle farm wastes, sustain soil health, conserve biodiversity and upgrade the farmers socio economic status. Farming should, of course be profitable. But it must also be sustainable. And who is better to understand that than farmers.

Keywords: *productivity, sustainable, STCR-IPNS, improve, economic, farmers*

Nutrient release pattern of different fertilizer doses and IPNS

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An incubation experiment was conducted to assess the nutrient release pattern of varying fertilizer doses and organic manure for 80 days. The soil of the experimental field belongs to Bahour soil series (*Typic Ustropept*) which occupies 12.72 per cent soils of Pondicherry district. The soil belongs to fine, mixed, isohyperthermic, *Typic Ustropept*. The incubation experiment was carried out with ten treatments *viz.*, farmer's practice, FYM alone @ 12.5 t ha^{-1}, blanket recommendation, STCR-NPK alone @ 160, 170 and 180 q ha^{-1} bhendi yield target and STCR-IPNS @ 160, 170 and 180 q ha^{-1} yield target and control with three replications. The incubation experiment was carried out for 80 days during which time the soil samples were drawn at 0, 40 and 80 days of incubation and analyzed for P fractions (Bolan and Hedley, 1989). The results thus obtained were statistically scrutinized and correlation and simple linear regression analysis was fit to compute the rate of change or release in soil properties.

Among the P fractions, the NaCl-P and NaOH-P content was increased upto 40th day of incubation. In the case of organic manure added treatments either with STCR or with blanket recommendation the concentration of NaCl-P and NaOH-P decreased at 40 DAI and thereafter increased. The decline in concentration of HCl-P in organic manure added treatments confirmed the release of available P through NaCl-P and NaOH-P. The simple linear regression had shown that HCl-P decreased at a rate ranging from 0.016 mg kg^{-1} day^{-1} in control to – 1.223 mg kg^{-1} day^{-1} in STCR + IPNS – 180 q ha^{-1}.

Key words: *Organic manure, P fractions, STCR*

Effect of organic manures, *bio-fertilizers*, levels of nitrogen and phosphorus on growth and yield of Soybean

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An expriment entitled "Effect of organic manures, bio-fertilizers, levels of nitrogen and phosphorus on soybean [Glycine max (L.) Merrill]" was conducted during 2014 at Tribal Research cum Training Centre, Anand Agricultural University, Devagadh Baria, 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 sixteen treatment combinations each of two organic manures (vermicompost @ 2.5 t ha^{-1} and FYM @10 t ha^{-1}), levels of nitrogen (22.5 and 45 kg N ha^{-1}), levels of phosphorus (30 and 60 kg P_2O_5 ha^{-1}) and biofertilizers (No biofertilizer and *Rhizobium* + PSB). The experiment was laid out in randomized block design with factorial concept. The soybean variety NRC-37 was used in the experiment as a test crop. Significantly the highest seed yield (1760 kg ha^{-1}, 1809 kg ha^{-1} and 1843 kg ha^{-1}) of soybean was found with the application of vermicompost @ 2.5 t ha^{-1}, 60 kg P_2O_5 and seed treatment of *Rhizobium* + PSB, respectively.

Improved strategies for sustainable sugarcane and sugar production

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Sugarcane is the most important long duration cash and agro industrial crop which is being cultivated in around 5.06 million hectares area in India. It produces large quantities of biomass and thus naturally add the nutrients in proportional quantities. The nutrients need replenishment through the addition of manure and fertilizers in the soil. Now days the chemical fertilizers have become more expensive and their use over a long period causes an environmental pollution which is not in favour of social, welfare, health and economy of the country. The major producing states are Uttar Pradesh, Maharashtra, Tamilnadu, Karnataka and Gujarat in which Uttar Pradesh is leading state having the average cane productivity 80.42 t/ha with sugar recovery 11.48 per cent. Chemical fertilizers have the capacity to supply only one or two plant nutrients but organic sources improve the physical, chemical and biological condition of soil as well as long term supply of plant nutrient to sugarcane. It is essential to encourage the practice of organic farming. Integrated use of organic manures with chemical fertilizers has the capacity to sustain the sugarcane and sugar production through the optimum utilization of nutrients. Application of dry leaves of sugarcane as a trash mulch was found to increase organic matter content of soil, save irrigation water and increases the microbial activities. Organic sources of nutrients is becoming increasing popular in the country because it supplies number of macro and micro nutrients essential for healthy growth and development of sugarcane plant. The possibility of using organic manures, press mud cake, bio fertilizers and trash mulch as basic component of organic farming for sustaining the sugarcane production. Increasing the productivity of sugarcane through also subsoliling, soil health card based nutrients application, adoption of modified paired trench planting method, mechanization, avoidance of burning sugarcane trash and nutrients management through organic source. Use of 10 t FYM per ha + inorganic nutrients on soil test basis +10 kg per hectare biofertilizers (PSB+Azotobacter each) have proved better for cane yield and sugar productivity (Report of AICRP at UPCSR AS 68). In ratoon, trash mulching found better with 10 kg per ha organo decomposer.

Keywords: *Sugarcane, sustainable, strategies, organic*

Nutrient uptake of container grown elephant foot yam as influenced by growth medium, nutrient schedule and irrigation schedule

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An experiment was done in the Instructional Farm, College of Agriculture, Vellayani to study the effect of growth medium, nutrient schedule and irrigation schedule on nutrient uptake of container grown elephant foot yam by raising elephant foot yam var. Gajendra in plastic sacks of uniform size with 12 treatment combinations involving three growth media (M_1 - soil : sand : FYM 1:1:1, M_2 - soil : coir pith : FYM 1:1:1 and M_3 - soil : coir pith : FYM 0.75:1.25:1), two nutrient schedule (N_1 – N and K in three splits and N_2 – N and K in six splits) and two irrigation schedule (I_1 - irrigation once in three days and I_2 - irrigation once in six days) with four replications in completely randomized design. Corm pieces of 250 g, treated with Trichoderma – cow dung slurry and shade dried, were planted in each sack. The calculated quantities of groundnut cake, bone meal and wood ash based on their nutrient contents were applied in each sack according to treatments. Uniform dose of bone meal was applied as a single basal dose in all sacs prior to planting of corm. Measured quantity of water, calculated based on evaporation data was applied at different intervals as per the treatments. Based on the result of this study, the growth medium had profound influence only on N and P uptake and the growth medium M_2 registered the highest uptake of N and P. Significant effect of nutrient schedule was observed with respect to N and K uptake when application of N and K in six splits (N_2) and it was found superior than three splits (N_1). Irrigation once in three days (I_1) recorded significantly higher N, P and K uptake than once in six days (I_2).

Keywords: *Nutrient uptake, Elephant foot yam, Growth medium, Nutrient schedule, Irrigation schedule*

Soil organic carbon and its fractions as affected by integrated use of organic and fertilizer under blackgram of the foothill Himalayas

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Soil is currently seen as the most relevant carbon sink and the most effective carbon stabilizer. This organic carbon (OC) is essential for several soil properties and plays an extremely important role in sandy soils in the foothill Himalayas. The objective of this study was to characterize the soil organic carbon and its fractions in relation to the application of farm yard manure (FYM) along with biofertilizers (rhizobium and phosphorus solubulizing bacteria) and inorganic fertilizers under blackgram. A total of 13 treatments were replicated thrice in randomized block design in a sandy loam viz.T_1: Control, T_2: P20 + PSB, T_3: P20 + PSB + Rhizobium, T_4: P20 + PSB + Rhizobium + FYM, T_5: P20 + 0.5Mo + PSB, T_6: P20 + 0.5Mo + PSB + Rhizobium, T_7: P20 + 0.5Mo + PSB + Rhizobium + FYM, T_8: P40 + PSB, T_9: P40 + PSB + Rhizobium, T_{10}: P40 + PSB + Rhizobium + FYM, T_{11}: P40 + 0.5Mo + PSB, T_{12}: P40 + 0.5Mo + PSB + Rhizobium, T_{13}: P40 + 0.5Mo + PSB + Rhizobium + FYM. Application of FYM along with inorganic sources and biofertilizers under T_{13} recorded highest labile carbon (LC), particulate organic carbon (POC) and microbial biomass carbon (MBC) concentration while as soil organic carbon did not exhibit any significant outcome during both the years. The bulk density was recorded lowest in plots incorporated with FYM + inorganic fertilizers. Integrated use of farmyard manure with P_{40} + 0.5 Mo + Rhizobium and PSB emerged as the most efficient management system in accumulating largest amount of labile carbon in soil. The grain yield and uptake of N, P, K and Mo by blackgram significantly improved under treatment T_{13} during both the years. Nevertheless, this treatment (T_{13}) emerged the best treatment in terms of soil carbon fractions as well as yield and uptake by the crop. These results conclude that the for maintaining soil quality and crop production, input of manure like FYM is of major importance and should be preferred in the nutrient management for improving soil fertility and properties of soils.

Keywords: *Carbon pools, Blackgram, Phosphorus, Molybdenum, Grain yield, Nutrient uptake*

Effect of Zinc and Boron on Growth, Yield, Bulb quality and Nutrient uptake of Onion (*Allium cepa* L.) cv Bhima Super under Mid-Central Table Land Zone of Odisha, India

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Present study was conducted at the Experimental Farm of the Regional Research and Technology Transfer Station, Mahisapat of Dhenkanal district which is situated in Mid Central Table Land zone of Odisha during Rabi 2016-17 and Rabi 2017-18 with six treatments which were arranged in Randomized Block Design with four replications as follows: T1- Soil Test Based Fertilizer Recommendation (STBFR) , T2- STBFR+ Soil application of Boron @1.0 kg/ha, T3- STBFR + soil application of Boron @0.5 kg/ha + Foliar spray of Borax @ 0.2% two times at 30 & 45 DAP , T4- STBFR + Soil application of Zinc @5 kg/ha, T5- STBFR+ Soil application of Zinc @2.5 kg/ha +Foliar spray of ZnSO4@0.5% two times 30 &45 DAP, T6- STBFR+ Soil application of Boron @1 kg/ha &Zinc @5 kg/ha . Obtained results indicated that application of micronutrients like Boron and Zinc to onion crop have significant impact on production of better bulb quality in terms of TSS and also provided better yield and nutrient uptake. Among all the treatment schedule, it was observed that the treatment schedule, T6 i.e., STBFR+ Soil application of Boron @1 kg/ha &Zinc @ 5 kg/ha significantly recorded highest bulb diameter (6.79 cm), bulb weight (72.57 g) resulted highest bulb yield (243.0 q/ha). The available nutrient content in bulb (1.58%, 0.5% and 1.59% of N,P and K respectively) and nutrient uptake in bulb (141.45 kg/ha, 11.27 kg/ha, 112.00 kg/ha of N, P, K respectively) are also found to be highest in T6 which was significantly higher than rest other treatments.

Key words: *Zinc, boron, onion, growth, yield, uptake*

Energetics of organic nutrition in direct seeded rice

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Efficient use of energy resources in agriculture is one of the principal requirements for sustainable agricultural production. It provides financial savings, fossil resource preservation and reduces pollution. For enhancing the energy efficiency, it must be attempted to increase the production or to conserve the energy input without affecting the output. Therefore, development of energy efficient agricultural systems has a crucial role in sustainable agricultural production. It has been suggested that organic agriculture can provide a more energy efficient approach due to its focus on sustainable production methods. But little works were done to assess the energy efficiency of organic rice-based cropping systems. With this in view, field studies were conducted during the kharif seasons of 2013 and 2014 at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University, to evaluate the energy efficiency of direct seeded rice under organic and conventional methods of rice cultivation. The treatments consisted of five nutrient schedules. T1- Adhoc organic package of practices recommendation of KAU (substitution of 1/3rd recommended dose of nitrogen (RDN) (90 kg N ha^{-1}) by farmyard manure (FYM), 1/3rd by vermicompost (VC) and 1/3rd by neem cake (NC) + Azospirillum @ 2 kg ha^{-1} and P solubilising bacteria @ 2 kg ha^{-1}), T2-100% RDN as organic (FYM @ 5 t ha^{-1} + 1/2 RDN by FYM + 1/4 by VC + 1/4 by NC), T3-75% RDN as organic (FYM @ 5 t ha^{-1}+1/2 RDN by FYM + ¼ RDN by VC + 1/4 RDN by NC), T4- Integrated nutrient management (INM) (KAU POP recommendation- FYM @ 5 t ha^{-1}+ 90 :45 :45 kg NPK ha^{-1}) and T5- Absolute control (without manures/fertilizers). In the present study, all the organic treatments were found to be more energy efficient than INM. The organic treatment produced more physical output per unit of energy input (energy productivity) and also required lesser energy to produce unit quantity of output (specific energy) compared to INM. But the energy output per rupee invested (energy intensity) was more in INM than organic treatments. 100 and 75 per cent POP as organic were 15.14 and 10.92 per cent more energy efficient and produced 15.16 and 10.93 per cent more output per unit of energy input than INM. The specific energy of 100 and 75 per cent POP as organic were 12.32 and 9.54 per cent lower than INM. The energy intensity was 34.18 and 34.53 per cent higher in INM than 100 and 75 per cent POP as organic respectively. From the present study, it could be concluded that application of 100 per cent RDN as organic and 75 per cent RDN as organic can be recommended as the most energy efficient organic nutrient schedule for direct seeded rice.

Keywords: *organic farming, direct seeded rice, energetics, energy efficiency*

Performance of Mole Drainage and its Economic Feasibility for Drainage of Irrigated Vertisols

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In Vertisols, water drains down very slowly. Therefore, it requires very closely spaced drains of 2 to 10 m for the successful drainage. In most situations this would be too expensive using underground pipes used for subsurface drains (Rs.2,50,000 ha^{-1} for 8-10 m spacing) and would be almost impractical with open ditch systems. A viable alternative under such circumstances could be mole drainage, which is pipe less or trenchless drainage system. Therefore, the performance of mole drainage were tested continuously for three years (2010-11 to 2012-13) by conducting field experiments with mole spacings of 2, 4, 6 m with 0.60 m depth and without mole drains in a randomized block design with five replications at Agricultural Research Station, Kasbe Digraj, Dist. Sangli (M.S.). The cost of mole drainage at 2, 4 and 6 m spacing of mole drains were around Rs. 6000, 4000 and 2000 ha^{-1}, respectively. Four mole drain laterals of each spacing were connected to sub-main drain of PVC pipe and then to an inspection chamber. The mole drains were formed from outlet side to upstream side with longitudinal gradient of 1.5% during first week of January. The moisture content and clay content at moling depth were 28% and 58% respectively. Groundnut in summer, soybean in *Kharif* and chickpea in *Rabi* season were grown continuously for three years (2010-11 to 2012-13) after installation of mole drains and found that the pooled mean yields of groundnut (kernel yield), soybean and chickpea were recorded significantly highest under 4 m mole spacing i.e., 15.20, 17.25 and 16.23 q ha^{-1} respectively followed by 6 m mole drain spacing. The lowest groundnut kernel yield (7.69 q ha^{-1}) was recorded in 2 m mole spacing due to excessive drainage of irrigation water (drainage coefficient 27.62 mm d^{-1}) as it was cultivated just after installation of mole drains. Whereas, the lowest yields of *Kharif* soybean (11.20 q ha^{-1}) and *Rabi* chickpea (6.45 q ha^{-1}) were recorded under without drained plot. An additional yield of groundnut, soybean and chickpea in 4 m spaced mole drained plot resulted an additional income of Rs. 94805 ha^{-1} $year^{-1}$. Further, this mole drainage technology with 4 m mole spacing were transferred on 80 ha sugarcane area of 200 farmers' field during 2016-17 to 2019-20 under Rashtriya Krishi Vikas Yojana-Farmer FIRST project. The average cost required for mole drainage was Rs. 4000 per ha. All benefitted farmers recorded on an average of 35.53% increase in sugarcane yield (37 t ha^{-1} yield increase) over without mole drained plot. The average additional net benefits of Rs. 88,500 ha^{-1} were gained by beneficiary farmers. The B:C ratio of sugarcane cultivation with mole and without mole drainage were 2.32 and 1.76, respectively. Hence, this low cost mole drainage technology with 4 m mole spacing and average depth of 0.6 m is recommended for better crop productivity in poorly drained and irrigated Vertisols of Maharashtra.

Keywords: *Chickpea, economic feasibility, groundnut, mole drainage, mole spacing, soybean, sugarcane and Vertisols.*

Economic Analysis of Traditional Goat Rearing by *Gurjars'* Folks of Bharatpur District of Rajasthan, India

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Gurjars' community is known for goat rearing as their sole occupation sustaining on waste lands of Bharatpur district in Rajasthan since centuries. The present study introspected economic aspects of traditional goat rearing by *Gurjars*' under field conditions. A survey was conducted during 2019-20 in Bharatpur district of Rajasthan to find out the economics of goat rearing. A total of 240 goat farmers belonging to 18 villages spread in six blocks were selected using multi-stage random sampling techniques. Among the selected farmers 46.32% were belonging to small holder category (1-5 goats/family). Capital investment per goat was highest in medium holder category (6-10 goats/family) and lowest in small holder category of farmers. The variable and fixed costs shared 83.54 and 16.21% of the gross cost. The labour cost shared 69.24% of variable cost and interest on investment shared 15.17% of fixed cost. Gross cost per goat decreased with increase in herd size. Income from sale of kids/adults contributed (58.47%) to return followed by sale of milk (43.12%) and manure (5.70%). Net income was maximum in large herd size and minimum in small herd size. Income and employment generation also increased with increase in herd size. It was concluded that goat rearing plays a vital role in generating income and employment to farmers in the Alwar district of Rajasthan. The study suggested that *Gujars'* community of Bharatpur district engaged in goat rearing as their sole and profitable occupation.

Keywords: *Gurjars' community, economic, traditional, goat farming and Rajasthan*

Influence of organic amendments on soil properties and C sequestration potential of soil

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Among the several problems affecting the developed world, soil impoverishment by over cropping or abuse of mineral fertilization should be subjected to special attention as it results to decline in soil health and consequent fall in crop productivity. The physical and biological health of the soil plays a key role in maintaining its productive capacity. Organic amendments are the alternative sources of nutrients which have tremendous potential to improve soil organic matter status and crop productivity, thereby rejuvenating and enhancing the dying total factor productivity of Indian soils. The amount of alternative sources of organic amendments available in the country are enormous for recycling and bio-conversion, to utilize their embedded nutrients and organic matter for sustainable soil health and crop production. Soil organic matter plays an important role in long-term soil conservation and/or restoration by sustaining its fertility, and hence in sustainable agricultural production, due to the improvement of physical, chemical and biological properties of soils. In addition, organic nutrient management produces safe plants free from chemical residues and contaminates. Organic amendments such as MSW compost, vermicompost, sewage sludge, anaerobic digestate are abundantly rich in organic matter and beneficial plant nutrients, having positive effects on soil physical properties (bulk density, aggregate stability, water holding capacity and porosity), chemical properties (pH, soil organic carbon and nutrients availability) and biological properties (microbial biomass carbon and different enzymatic activity). Organic amendments, once added to the soil, favour the growth and diversity of microbial communities, highlighting a strong correlation between soil biological property and soil organic C content. Long-term organic amendment application plays a positive role in climate change mitigation by soil carbon sequestration and is a sustainable alternative to chemical fertilizers, which in turn can reverse the process of soil degradation. Most importantly, sole application of organic amendments cannot meet the nutrient requirements of the crops; hence they should be used in conjunction with inorganic fertilizers for maintaining the desired crop productivity.

Keywords: *Organic amendments, soil quality, C sequestration, sustainability, nutrient management*

Studies on Physico – Chemical and biological properties of soil in different cropping sequences of Thakurdwara Tahsil of Moradabad district

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The depth wise soils of various cropping sequences from different locations were analysed to find the physico – chemical properties like soil texture, bulk density, pH, EC, CEC, organic carbon, total nitrogen, macro- micronutrients and biological properties (Bacteria, Fungi, actinomycetes count, microbial biomass, carbon and dehydrogenase). The soil samples collected from 10 locations of four different cropping sequences varied in texture. The clay ranged from 9.42 to 33.84 and sand 47.28 to 67.86 percent. Substantial translocation of clay was noted specially in case of CRC (M) soil. The bulk density ranged from 1.11 to 1.32 Mg m^{-3} and it increases with declining organic carbon and increasing soil depth. The pH of soil samples varied from 7.2 to 8.6. The range of electrical conductivity of 1:2 soil water extraction was 0.092 to 0.644 d Sm^{-1} at 25 ^{0}C. None of the soil was found in saline category. CEC of soil varied from 6.43 to 31.91 cmol (p^+) kg^{-1} soil. Generally CEC was positively and significantly correlated with clay content. The organic carbon content which decline with soil depth varied from 1.7 to 8.6 g kg^{-1} soil. Organic carbon was correlated positively and highly significantly with available nitrogen, total nitrogen, positively with available P, K, micronutrient and microbial biomass carbon and negatively with Bulk density and CEC in all the cropping sequences soil. The available nitrogen ranged from 48.44 to 184.05 kg ha^{-1}. It decline with soil depth. Total nitrogen in soil decline with increasing soil depth and ranged from 422.27 to 2124.78 kg ha^{-1}. The available phosphorus and potassium ranged from 9.02 to 35.03 and 82.25 to 591.41 kg $ha^{-1}$and declined with increasing soil depth. Among the different cationic micronutrients with exception of zinc the availability of rest micronutrients was in sufficiency range. In some case the availability of zinc was in deficient range. DTPA extractable Cu ranged from 0.067 to 8.939, Fe 1.947 to 16.923, Mn 0.482 to 8.259 and Zn 0.083 to 1.702 mg kg $^{-1}$ soil. The availability of these micronutrients declined with increase in soil depth. Except Mn and available potassium others nutrients were significantly and positively correlated with organic carbon. Among the biological properties of soil, the range of bacteria varied from 2.0x 10^2 to 6.5x 10^8, Fungi 1.0x 10^2 to 8.6x 10^4 and actinomycetes 1.0x 10^2 to 8.0x10^4 count g-1 soil. Microbial biomass carbon 75 to 400 µg g-1 soil and dehydrogenase activity 10 to 90 µg TPF g-1day-1. All the microbial population, microbial biomass carbon and dehyrogenase activity decline as the soil depth increases.

Keywords: *Thakurdwara, soil properties, soil enzymes, micronutrients*

Availability of macro and micro nutrients in different four blocks of Moradabad district of Uttar Pradesh

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Soil is one of the most important vital natural resource, defends the life supporting system of a country and socio-economic development of its people. More than ever before, a renewed attention is being given to soil due to rapid declining land area for agriculture, declining soil fertility and increasing soil degradation, wrong land policies and imbalance use of inputs**.** All the above factors call for a paradigm shift in research away from maximum crop production to the sustainability of crop production system without degradation of soil health and environmental quality. Soils differ greatly in their morphological, physical, chemical and biological characteristics. Since these characteristics affect the response of soil to management practices it is necessary to have information about these characteristics of each category of soil. Soil fertility is one of the important factors controlling yields of the crops. Within a soil, nutrient variability exists depending upon the hydrological properties of the soil and cropping system. In the present study 55 soil samples were collected from different four block namely 1. Thakurdwara.2. Dilari.3. Chhajlet.4. Bhagatpur Tanda of Moradabad districts and collected soil samples were analyzed. The processed soil samples were analyzed by standard methods. The pH varied from 5.8 to 8.8. Organic carbon content varied from 3.2 to 8.3 g Kg-1 soil. The available N content was varied from 90.66 to 285.31 kg ha-1.The available phosphorous content varied from 11.71 to 57.23 P_2 O5 kg ha-1 .Status of available potassium in the ranged from 110.20 to 235.23 K_2O Kg ha-1. Cu in the surface soil was found to sufficient and varied from 0.390 to 1.813 mg kg-1. The iron content varied from 3.931 to 16.123, Mn from 0.572 to 3.012 mg kg-1. The available Zn in surface soil ranged from 0.213 to 1.321 mg kg-1 soil. Nutrient status regarding to the available macro and micro nutrient in surface soil indicate that soils are low in available N and medium in available P and K and in general marginal in available Cu,Fe, Mn and Zn. Normal to slightly alkaline in reaction, low to medium in organic carbon content.

Keywords: *Soil fertility, Nitrogen, Phosphorus, Organic matter, Analysis*

Dissemination of microbial technologies for empowering rural weaker section

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Microbial bioconversion of waste agricultural, household or other natural products like leaf litter and other non-decomposed matter into valuable products like organic farm inputs has been worked out as microbial technology in the past several years. The high-value organic farm-input production using microbial bioconversion processes and its applications in the farmers' field for the production of high value crops especially commercial crops like vegetables, fruits, flowers and organic crops are eco-friendly options for farming as well as agrowaste management. Also microbes for plant growth promotion and nutrient uptake are providing options for low input ecofriendly technologies in farming system which can be integrated in composting to produce enriched compost. These microbial technologies when capitalized by the ways of their mass penetration in the rural society through popularization and support service provisions from the scientific communities working together with the farmers' can make a visible and countable change in the economy generation, integrated on-farm management and sustainable farming systems through rural livelihood generation and eco-enterprising. Hence there is need for proposed microbial technological intervention to be propagated into the farming communities to promote production of low-cost bio-composts by the farmers at their own fields using their own agro-waste resources, enriching bio-compost into better and more effective farm-product with the use of microbial inoculants and its application in fields for better crops and/or alternatively, generating income through enterprising the products. Through Department of Science and Technology funded project at ICAR-National Bureau of Agriculturally Important Microorganisms, Mau we aim to disseminate the microbe-fortified compost production technology standardized at the ICAR-NBAIM, Mau among the rural and weaker section of society at Mau and Azamgarh districts. Cropping patterns of the SC farmers in these districts is mostly Rice-Wheat cropping system but, marginal farmers also grow vegetable crops for their livelihood. The socioeconomic status of the targeted population is low. The technology developed at ICAR-NBAIM, Mau on rapid Composting of Agro waste and production of value-added fortified compost using microbial Inoculants was identified and has potential of producing low-cost high value compost that when used in the farms can add carbon content and minerals to the soils and enhance crop productivity. Within these districts, a total of 10 villages from based on the population of weaker sections (SC community) were selected and activities are being implemented among the farmers. So far training and demonstration programs were conducted in the Surabhojh, Bhar and Haldharpur villages of Mau, at KVK Azamgarh for farmers of more than 15 villages and a total of 579 farmers were disseminated with the microbe-fortified compost production technology in the selected village of Mau and Azamgarh out of which 269 were women. Farmers were trained on the technical aspects of the technology and promoted to perform repetitive exercise for producing

compost from the agrowaste available at their own farms. We encouraged them to use microbial inoculants for raising compost quality and for this, the inoculants were provided during the training cum demonstration programs for free. The adoption of the technology is easy and viable and can be easily utilized in the farms or commercialized for economic values.

Keywords: *Microbial technology; Compost, Fortified compost, dissemination, rural weaker sections*

Effect of fertilizers on Turmeric (*Curcuma longa*) and Guava (*Psidium guajava*) yield under agri-silvi-horti system on partially improved sodic soil

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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 R.B.D. design with four replications in five treatments. The maximum fresh weight of *C. longa* rhizome (5.64 t ha^{-1}) and *P. guajava* fruit yield (6.52 t 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.

Keywords: *Sodic soil, Psidium guajava, Casurina equsitifolia, Curcuma longa and fertilizers*

Waste conversion efficiency of popular composting methods and characterization of various organic manures

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Soil organic matter (SOM) plays a pivotal role in maintaining soil quality and agricultural sustainability. The good management of organic wastes through composting serves as an effective means of organic matter restoration through carbon restitution to the depleted soils through organic amendments. The new thermochemical waste processing method reported by Sudharmaidevi *et al.* (2017), provides a quick and sustainable solution for hygienic waste disposal and the production of organic manure. In the present study organic manures prepared in four different methods along with FYM were characterized for its various physical and chemical properties. Three conventional methods i.e. aerobic composting, accelerated composting using microbial inoculum, vermi composting and one non-conventional method i.e. KAU rapid thermochemical decomposition were used for the preparation of organic manures and the waste conversion efficiency of all methods were also evaluated. The aerobic compost (AC), microbial compost (MC), vermi compost (VC), and thermo chemical organic fertilizer (TOF) were prepared from identical wastes with a definite proportion so as to make an effective comparison between the treatments. The TOF-F was prepared for the study by fortifying the TOF with N (1.5%) as groundnut cake, P (1%) as rock phosphate, Ca (1%) as calcium carbonate, Mg (0.5%) as magnesium sulphate, Zn (50 ppm) as zinc sulphate, and B (5 ppm) as borax. The physical properties of all the organic manures under study conformed to the quality standards of FAI (2017). All the manures were odourless with free-flowing texture except FYM which exhibited a lumpy texture when dried. The highest BD was recorded by AC (6.57 Mg m^{-3}) while the lowest was recorded by TOF (0.90 Mg m^{-3}). An analysis of the waste conversion efficiency of the different techniques used in the present study revealed that the most efficient method was thermo chemical decomposition since it took only one day for processing and production of TOF. The waste to manure conversion rate was also the highest in this process. The pH of all the organic manures was in the acidic range and the highest pH was recorded by TOF-F (6.98). All organic manures included in the study had a safe EC, and highest being recorded by TOF-F (0.657 dS m^{-1}). The total organic content (TOC) of all manures remained significant and the highest TOC (48%) was observed in the case of TOF. The dissolved organic carbon was detectable in traces in all manures. The organic manure MC had the highest value for $SUVA_{254}$.

Keywords: *Soil organic matter, Compost, Thermochemical organic fertilizer*

Soil fertility effects of red gram [*Cajanus cajan* (L.) Millsp.] under varying management practices in the southern laterites of Kerala

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Pulses are eminent soil enriching crops via the unique ability of biological nitrogen fixation. This makes them an integral component of almost all cropping systems, either as intercrops or in rotation with the other annual crops. Among pulses, red gram [*Cajanus cajan* L.) Millsp.] is cultivated in the central and northern parts of Kerala and is a new introduction in the south. Traditional varieties are mostly of longer duration (180 days) and finds lowered preference as these are preferably included in crop sequences. The field experiment on the suitability of short duration varieties of red gram under varying management practices was conducted in the Instructional farm, College of Agriculture, Vellayani, Kerala during November 2018 – March 2019 and the changes in soil chemical properties were assessed on soil samples after the harvest of the crop. The treatments included two short duration red gram varieties (v_1: APK 1 and v_2: Vamban (Rg)3), two spacings s_1: 40 cm x 20 cm, s_2: 60 cm x 30 cm and three nutrient levels (n_1: 40:80:40 kg NPK ha^{-1}, n_2: 30:60:30 kg NPK ha^{-1} and n_3: 20:40:20 kg NPK ha^{-1}). The soil of the experimental site was sandy clay loam belonging to the order Ultisols with extremely acidic pH, medium in organic carbon and available K, low in available N and high in available P status. The chemical analysis revealed improvements in the soil pH, organic C and NPK status and among the individual effects, the favourable effects were significant for the nutrient dose alone with the highest dose recording the highest nutrient status. The combination of the variety APK 1, 40 cm x 20 cm and 40:80:40 kg NPK ha^{-1} in red gram was found to bring about the significant enhancement in soil fertility suggestive of the possibility of reducing fertilizer nutrient inputs in the subsequent crop thus minimizing chemical pollution in the cropping system.

Keywords: *Fertility, nutrient, pulses, red gram, soil*

Effect of Organic Manures on the Growth of Wheat (*Triticum aestivum*) and Soil Enzymatic Activity

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Organic agriculture is a holistic production management system which promotes and enhances ecosystem health, including biological cycles and soil biological activity. Application of different organic manures in combination with organic fertilizers to wheat crop might give a substitute under pot condition. A pot experiment is conducted during 2012-13with the objective to find out best combination and type of organic and inorganic fertilizer for wheat (*Triticum aestivum*) production. The experiment was laid out with three replication. The treatments were: control (T1, NPK), 100+60+40 NPK Kg/ha+5ton/ha Farmyard manure (T2), 100+60+40 NPK Kg/ha+5 ton/ha Vermicompost (T3), 100+60+40 NPK Kg/ha+5ton/ha Paddy husk (T4), 100+60+40 NPK Kg/ha+5ton/ha+2.5 ton/ha Farmyard manure+2.5 ton/ha Vermicompost (T5). After 60days spike length (cm), root length (cm) and number of spikelet's recorded. The soil enzymes dehydrogenase, urease, acid and alkaline phosphatase activity was measured. Enzyme activity in soil is regulated by pH and microbial biomass, which is correlate to soil organic manures content, as well as to soil compaction. The laboratory experiment is conducted in order to monitor the decomposition of vermicompost, paddy husk and farmyard manure when applied in soil under field condition. The rate of decomposition of organic manures was determined in terms of mg of CO2 evolution per 100g of soil.

Key words: *NPK (Nitrogen, Phosphorus, Potassium), Vermicompost, Farmyard manure, Paddy husk, dehydrogenase, urease, acid phosphatase, alkaline phosphatase, organic manure, spike length, root length, pot experiment, laboratory experiment*

Soil health and nutrient management for sustainable productivity

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Soil health is continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. This speaks to the importance of managing soils so they are sustainable for future generations. Organic farming aims to build up, or at least maintain, soil nutrient reserves whilst at the same time maximizing nutrient recycling and reducing external inputs. Efficient management of nutrients, soil structure and soil biology should ensure good sustainable productivity of crops. Degradation of soil fertility due to use of synthetic agro-inputs is considered as one of the most important factors affecting sustainability of agricultural systems. Several indicators for the sustainability of agricultural systems have also been developed. Use of synthetic fertilizers and their effects on crop production, soil health, environmental quality, biodiversity conservation and self-reliance of farming system have been discussed in the context of agricultural sustainability. Degradation of soil fertility due to use of synthetic agro-inputs is considered as one of the most important factors affecting sustainability of agricultural systems. Presence of soil organic matter and soil microbial population are primarily useful indicators of soil health and productivity of both crops and livestock Several indicators for the sustainability of agricultural systems have also been developed. Use of synthetic fertilizers and their effects on crop production, soil health, environmental quality, biodiversity conservation and self-reliance of farming system have been discussed in the context of agricultural sustainability. Degradation of soil fertility due to use of synthetic agro-inputs is considered as one of the most important factors affecting sustainability of agricultural systems. Presence of soil organic matter and soil microbial population are primarily useful indicators of soil health and productivity of both crops and livestock Several indicators for the sustainability of agricultural systems have also been developed. Use of synthetic fertilizers and their effects on crop production, soil health, environmental quality, biodiversity conservation and self-reliance of farming system have been discussed in the context of agricultural sustainability. Degradation of soil fertility due to use of synthetic agro-inputs is considered as one of the most important factors affecting sustainability of agricultural systems. Presence of soil organic matter and soil microbial population are primarily useful indicators of soil health and productivity of both crops and livestock.

Mitogen activated protein kinase (MAPK) signaling in plant disease resistance

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During their life time, plants always suffer from invasion of potential pathogenic microorganisms in the environment. To defend themselves against pathogen attack, plants have evolved a sophisticated immune system. Two types of innate immune responses, which are precisely regulated upon infection from different types of pathogens, have been recognized in plants so far. The first innate immune response is the pathogen-associated molecular pattern (PAMP)-triggered immunity (PTI), which is activated by a number of PAMPs such as flagellin and chitin. The other one is the effector-triggered immunity (ETI), which is modulated by recognition of pathogen-derived avirulence effectors by plant R genes. Much progress has been made in understanding the mechanisms by which plants detect and defend themselves against microbial attack. These include the identification of components involved in the signal transduction pathways coupling pathogen recognition to the activation of defense responses and the demonstration that three endogenous plant signaling molecules, salicylic acid (SA), jasmonic acid (JA) and ethylene (ET), are involved in plant defense. In the past few years, it has become apparent that mitogen activated protein kinase (MAPK) cascades play some of the most essential roles in plant signal transduction pathways from cell division to cell death. The first reports of plant MAPKs in 1993 identified extracellular signal regulating kinase (MsERK1) in alfalfa and D5 kinase in pea. Sequential phosphorylations ensue as MAP3Ks activate downstream MAP kinase kinases (MAP2Ks; also called MKKs or MEKs) that in turn activate MAPKs. MAPKs then target various effector proteins in the cytoplasm or nucleus, which include other kinases, enzymes, or transcription factors. Li *et al.*, 2014 identified a total of five SlMKK genes with one new member, SlMKK5 in tomato. qRT-PCR analyses revealed that expression of SlMKK2 and SlMKK4 was strongly induced by *B. cinerea* and by jasmonic acid and ethylene precursor 1-amino cyclopropane-1-carboxylic acid. Virus-induced gene silencing (VIGS)-based knockdown of individual SlMKKs and disease assays identified that SlMKK2 and SlMKK4 but not other three SlMKKs (SlMKK1, SlMKK3 and SlMKK5) are involved in resistance against *B. cinerea.*

Keywords: *MAPK cascade, MPK kinase, SlMKK2/SlMKK4, Botrytis cinerea, Defense response, Tomato (Solanum lycopersicum)*

Organic farming and management effects on soil health

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The concept of soil quality or health has received considerable scientific attention over the years. Soil quality or health is most often defined as the "capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health". It is unlikely that the same soil characteristics would be desirable in all environments or management systems. Instead of a fixed benchmark, soil quality is assessed by a suite of physical, chemical, and biological indicators which are interpreted in the context of the environment in which the soil occurs, whether natural or managed. In general, soil quality is inextricably linked to soil carbon (C) and organic matter (OM) dynamics, which in turn directly influence soil physical, chemical, and biological function. Soil organic matter (SOM) depletion is linked to the decline of soil quality and is highly susceptible to management strategies. The links between soil quality, long-term soil productivity, and environmental quality are now widely acknowledged, as is the importance of conserving soil as a resource for future generations. Less clear is whether soil health, per se, has a direct effect on human health through food quality. The terms soil quality and soil health are usually used interchangeably, with soil quality often preferred by scientists and soil health by farmers. Well-managed organic farms generally have enhanced soil quality compared to neighbouring conventional farms. Recent reviews and meta analyses confirm organic farming systems generally increase soil organic C, a key indicator of soil quality, even under zero net-input conditions. It is generally thought that differences in soil quality are due to the greater reliance of organic farms on longer rotations, organic inputs, and other soil building practices, not due to management differences intrinsic to organic farms per se. However, potential negative effects of pesticides combined with benefits of diverse OM inputs on the structure and function of soil microbial remains an ongoing and important area of study.

Keywords: *Organic farming, soil health, soil management, soil organic carbon*

Impact of Long Term Fertilization on Soil Properties and Soybean Productivity in a Vertisol

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The present investigation was conducted during 2018-19 under All India Coordinated Research Project on "Long Term Fertilizer Experiment" at the Research Farm Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.), which was commenced since 1972, to assess the effect of continuous application of different fertilizer with or without organic manure on soil fertility and soybean productivity. There was ten treatments i.e. T_1 (50% NPK), T_2 (100% NPK), T_3 (150% NPK), T_4 (100% NPK + Hand weeding), T_5 (100% NPK + Zn), T_6 (100% NP), T_7 (100% N), T_8 (100% NPK + 5 t FYM ha^{-1}), T_9 (100% NPK-S) and T_{10} (Control), which replicated four times in a randomized block design. The findings of the present investigation revealed that the application of recommended dose of N, P and K (20:80:20 kg ha^{-1}) with organic manure (@ 5 FYM ha^{-1}) enhanced soybean crop yields over control plot. Further, the integrated use of FYM with 100% NPK substantially improved the organic carbon content by 2.9 g kg^{-1} as well as available N and P in soil over its initial values, thereby indicating significant contribution towards sustaining the soil health. On the other hand, a declining trend (238 to 333 kg ha^{-1}) from its initial value (370 kg ha^{-1}) of available K status was also observed as a result of continuous cropping, this indicates considerable soil mining of available K. However, the decline of K was of lower magnitude with 100% NPK + FYM (10.0%) and 150% NPK (15.1%) treatments indicating the need to raise the level of K fertilizer application to meet demand of the crops. However, the fertility of the soil appears to be adversely affected due to the imbalance use of nutrients viz. NP or N alone. Thus, the balance use of fertilizers continuously either alone or in combination with organic manure is necessary for sustaining soil fertility and soybean productivity.

Keywords: *Soybean yield, FYM, LTFE, Organic Carbon, Vertisols*

Distribution of Available Silicon in Rice growing Soils of Jammu Plains

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Silicon (Si) is a beneficial element which influences the growth, development, and yield of many crop plants especially rice. Rice is known as silicon accumulating plant because of its high requirement which contains Si at levels up to 10 % dry matter weight. It is estimated that to produce grain yield of 5.0 t ha^{-1}, rice crop removes 230-470 kg Si ha^{-1} from soil, thus Si may be a yield limiting element for rice production particularly in soils deficient or low in available silicon. Moreover, the plant available Si in the form of soluble silicate is seriously limited by its low solubility. Si has been reported to benefit rice in a number of ways, like improvement in efficiency of sunlight use and increase in photosynthetic activity, reduction in transpiration and improvement in water use efficiency by keeping leaves erect and compact, increased mechanical strength of cells and reduction in lodging, increased resistance to certain insects and diseases. Nitrogen fertilization tend to make rice leaves droopy, where as Si keep them erect which enhances photosynthetic efficiency resulting in increased yield. Adequate supply of Si to rice from tillering to stem elongation stage increases the number of grains per panicle and the percentage of ripening. The present study was undertaken to generate primary information regarding the distribution of available Si in some rice growing soils of Jammu plains. In the present investigation, 140 number of surface (0-15 cm) soil samples were collected from rice growing plains of Jammu, Kathua and Samba districts and were analysed for plant available silicon (PA-Si) using extractants such as 0.01*M* Calcium chloride, 0.5*M* Ammonium acetate and 0.5*M* Acetic acid besides other physico-chemical properties. The textural class of soils was sandy loam to clay loam. The soils under three districts were moderately acidic to moderately alkaline in reaction with limited salt content. The soil organic carbon, available phosphorus, available potassium and available sulphur varied from low to high and the available nitrogen content in soils varied from low to medium in the three districts. However amongst the three districts, highest mean organic carbon content (7.04 g kg^{-1}) was observed in Jammu district followed by Kathua district and lowest was observed in Samba district. In respect of macronutrients, highest mean value of available nitrogen (293.2 kg ha^{-1}) and potassium content (201.9 kg ha^{-1}) was found in Kathua district whereas highest mean value of phosphorus (25.1 kg ha^{-1}) and sulphur content (18.1 mg kg^{-1}) was found in Jammu district. Extraction pool of plant available Si was found maximum by 0.5*M* acetic acid followed by 0.5*M* ammonium acetate and least by 0.01*M* calcium chloride which were positively correlated to each other. The mean value of available soil silicon extracted by 0.01*M* calcium chloride was 227.6, 261.7 and 226.0 mg kg^{-1} for Jammu, Kathua and Samba districts, respectively which was found to be sufficient, however, few locations contain low level of available silicon.

Keywords: *Silicon, rice, chemical properties, available nutrients, Jammu plains*

Soil Health: Way Forward to Enhance Sustainable Production

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Soil health is the ability of a alive soil to function, within innate or managed ecosystem borders, to prolong plant and animal output, maintain or enhance water and air quality, and encourage plant and animal health. Optimal soil health requires a equilibrium between soil functions for output, environmental eminence, and plant and animal wellbeing all of which are greatly affected by management and land-use decisions. High-quality supervision practices that consider soil health must consider all functions, rather than focus on single functions, such as crop productivity. Therefore, relationships of soil microorganisms formed by intimate associations with plants and animals strongly suggest that they are major contributors to soil health. The management practices for maintaining or improving soil health and environmental quality are depends on your situation because different kinds of soil respond differently to the same practice. Dropping tillage minimizes the loss of organic matter and protects the soil surface with plant residue. Tillage is used to loosen surface soil, prepare the seedbed, and control weeds and pests. But tillage can also break up soil structure, speed the decomposition and loss of organic matter, increase the threat of erosion, destroy the habitat of helpful organisms, and cause compaction. An significant function of soil is to buffer and detoxify chemicals, but soil's capacity for detoxification is limited. Pesticides and chemical fertilizers have valuable benefits, but they also can harm non-target organisms and pollute water and air if they are mismanaged. Compaction reduces the quantity of air, water, and space available to roots and soil organisms. Compaction is caused by repeated traffic, heavy traffic, or traveling on wet soil. Deep compaction by heavy equipment is difficult or impossible to remedy, so prevention is essential. Subsoil tillage is only effective on soils with a clearly defined root-restricting plow pan. Exposed soil is susceptible to wind and water erosion, and to drying and crusting. Ground cover protects soil, provides habitats for larger soil organisms, such as insects and earthworms, and can improve water availability. Ground can be covered by leaving crop residue on the surface or by planting cover crops. Diversity is beneficial for several reasons. Each plant contributes a unique root structure and type of residue to the soil. A diversity of soil organisms can help control pest populations, and a diversity of cultural practices can reduce weed and disease pressures.

Key words: *Tillage, Soil health, organic matter, productivity*

Nutrient availability in soil and tomato yield as influenced by compost sources and rice stubble management

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A field experiment was carried out to evaluate different composts and stubble management on nutrient availability and yield of tomato after winter rice. Tomato (*variety* - Anup) was grown (50 cm x 45 cm, row x plant) after harvest of winter rice (*variety* - Ranjit) in a sandy clay loam soil (pH 5.6, organic carbon 6.3 g kg^{-1} and low in available N, P and K) in the research farm of Assam agricultural University, Jorhat, Assam during December 2019 to April 2020. The experiment was conducted in a split plot design comprising individual plot size of 3.0 m x 3.1 m with four replications. Rice stubble was either removed or incorporated in the main plot, and each main plot was divided into five sub plots fertilized with different composts or recommended fertilizer dose (RFD). The nutrient management treatments comprised of unfertilized plot, RFD (farmyard manure 2 t ha^{-1} one week before planting followed by 75:60:60 $N:P_2O_5:K_2O$ kg ha^{-1} applied at planting, with N in two equal splits), biofertilizer (*Azotobacter* and PSB culture @ 2 g kg^{-1}) incubated (15 days incubation at 25±1% moisture, w/w) farmyard manure 2 t ha^{-1} (FYM), poultry manure 2 t ha^{-1} (PM) and vermicompost 2 t ha^{-1} (VC). The composts were applied in two equal splits at planting and at 30 days after planting (DAP). The NH_4-N and NO_3-N contents, and P and K availability in soil was maximum with application of RFD, while the lowest values were observed in the unfertilized plot. The available NH_4-N, NO_3-N and P contents of soil significantly increased in VC and PM applied plots compared to FYM or unfertilized plots and were at par with RFD. However, the available K content of soil was significantly higher in RFD at 28 and 56 DAP compared to all other treatments. The pH of the soil significantly increased in PM up to 42 DAP, while the lowest pH values were recorded in RFD and unfertilized plots throughout the tomato growth period. The highest tomato fruit yield was observed with RFD and was at par with PM or VC, which significantly differed over FYM and unfertilized plots. Incorporation of rice stubbles had a positive effect on nitrogen mineralization, availability of phosphorous, potassium and yield of tomato, but the interaction with nutrient management was not significant.

Keywords: *organic manure, crop residue, rice-fallow, nutrient recycling*

Influence of lime, farmyard manure, wood ash and rice stubble management on nutrient availability and tomato yield

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A field experiment was carried out to evaluate nutrient availability and tomato yield as influenced by lime and farmyard manure (FYM) with and without stubble addition in rice-fallow soil. Tomato (*variety* - Anup) was grown (50 cm x 45 cm, row x plant) after harvest of winter rice (*variety* - Ranjit) in a sandy clay loam soil (pH 5.6, organic carbon 6.3 g kg^{-1} and low in available N, P and K) in the research farm of Assam agricultural University, Jorhat, Assam during December 2019 to April 2020. The experiment was conducted in a split plot design comprising individual plot size of 3.0 m x 3.1 m with four replications. Rice stubble was either removed or incorporated in the main plot, and each main plot was divided into five sub plots fertilized with of nutrient management treatments. The sub plot treatments comprised of unfertilized plot, RFD (farmyard manure 2 t ha^{-1} one week before planting followed by 75:60:60 N:P_2O_5:K_2O kg ha^{-1} applied at planting, with N in two equal splits), ½ lime requirement (½LR) applied as quick lime at two weeks before planting followed by biofertilizer (*Azotobacter* and PSB culture @ 2 g kg^{-1}) incubated (15 days incubation at 25±1% moisture, w/w) farmyard manure 2 t ha^{-1} (FYM) at planting (½LR +FYM), ½LR at two weeks before planting followed by FYM and 2 kg ha^{-1} wood ash (ash) instant mixture at planting (½LR +FYM-ash), and ½LR, FYM and ash instant mixture applied in two equal splits at planting and 30 days after planting (½LR-FYM-ash). Application of RFD significantly increased NH_4-N, NO_3-N, available phosphorous and potassium content in soils throughout the growth period and was at par with ½LR-FYM-ash. In case of separate applications of lime and FYM (½LR +FYM) or lime and FYM-ash mixture (½LR +FYM-ash), no significant differences in nitrogen mineralization or available P and K contents of soil were observed, but increased significantly over unfertilized plot. The pH of the soil significantly increased up to 56 days after planting of tomato due to application of lime, irrespective of FYM and ash mixture or separate applications. Highest fruit yield of tomato was observed with RFD and was at par with ½LR-FYM-ash, and both differed significantly to rest of the treatments. Incorporation of rice stubble showed positive effects on tomato yield, NH_4-N, NO_3-N, available P and K in soil, however the interaction with nutrient management practices was not significant.

Keywords: *compost enrichment, crop residue, nutrient recycling, rice-fallow*

Organic Farming and Nutrient Management for Sustainable Development

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In organic farming, it's important to constantly work to construct a healthy soil that's rich in organic matter and has all the nutrients that the plants need. Several methods viz. green manuring, the addition of manures and biofertilizers, etc. can be used to construct soil fertility. These organic sources not only add different nutrients to the soil but also help to check weeds and surge soil organic stuff to feed soil microorganisms. Soil with high organic matter fights soil erosion, holds water better, and thus requires less irrigation. Some natural minerals that are needed by the plants to grow and to improve the soil's consistency can also be added. Soil amendments like lime are added to adjust the soil's pH balance. However, soil modification and water should contain minimum heavy metals. Most of the organic fertilizers used are recycled by-products from other industries that might otherwise go to the waste. Farmers also make compost from animal manures and mushroom compost. Before compost can be applied to the fields, it is heated and aged for at least two months, reaching and maintaining an internal temperature of 130°-140°F to kill unwanted bacteria and weed seeds. Several organic fertilizers/amendments and bacterial and fungal biofertilizers can be used in organic farming depending upon availability and their suitability to crop.

Keywords: *Biofertilizers, Green manuring, Organic fertilizers, Soil microorganisms, Soil erosion*

Carbon addition through residues in rice-rice cropping system under long term fertilizer experiment in an Inceptisol of Bhubaneswar, Odissa

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An investigation was carried out to study the quantity of carbon added through stubble incorporation and its effect on soil physical, chemical, biological properties and yield of rice in the long-term fertilizer experiment under rice-rice cropping system in an *Inceptisol* of Bhubaneswar. The field experiment was laid out in a randomized block design with four replications consisted of six treatments of FYM, lime and different levels of recommended dose of fertilizers (N:P:K= 80:40:60 kg/ha) *viz.,* (i) 100% NPK, (ii) 100% NPK + FYM 5t/ha per season, (iii) 100% N, (iv) 100% NP, (v) 100% NPK + Lime 1 t/ha per season, (vi) control. The quantity of stubble incorporated varied from 2998.9 to 6330.85 kg/ha, carbon incorporated ranged from 1223.5 to 2571.5 kg/ha, carbon stock 7.14 to 11.76 Mg/ha and SOC 3.35 to 6.13 g/kg. The quantity of stubble incorporated, carbon added, carbon stock and SOC were maximum in 100% NPK + FYM and minimum in control. Higher grain yield as well as total biomass was observed in 100% NPK+ FYM followed by 100% NPK + Lime, 100% NPK, 100% NP, 100% N and control. Correlation study of SOC with C added through stubble, C stock of soil was found to be significantly high. SOC showed very high correlation with CEC ($r=0.85^{**}$), available soil N ($r=0.84^{**}$), available P ($r=0.86^{**}$), available K ($r=0.75^{**}$), MBC ($r=0.83^{**}$), yield ($r=0.85^{**}$).

Keywords: *Carbon stock, rice-rice cropping system, stubble, SOC*

Crop Residue Management for Improving Soil Organic Carbon

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Soil organic matter (SOM) is the most important component determining the physical, chemical and biological properties of soil. Unfortunately, today's intensive agriculture is marked by the rampant use of chemical fertilizers and lower addition of organic manures. As a result, our soils are getting depleted of SOM. This can negatively influence soil health and hence crop production. Tropical agricultural ecosystems face severe degradation of soil due to reduced SOM content. This is mainly due to the decline in the amount of carbonaceous organic inputs supplied to the soil. Indian soils are depleted of soil organic carbon (SOC) and is in the range of 0.3 - 0.4 per cent and it should be 1- 1.5 per cent in order to maintain better soil health. Crop residues are potential sources of organic matter. Unlike the past concept of "organic wastes", crop residues are being realised as "valuable carbon inputs" which need to be recycled to the soil to improve SOM and hence SOC. Removal of crop residues from fields reduces SOC and leads to decline in soil fertility. Crop residue management is known to affect either directly or indirectly most of the soil quality indicators. Management options include incorporation, surface retention and mulching and composting of residues through vermicomposting, co-composting or microbial composting. Incorporation of residues is an alternative option to burning. It has several positive impacts on soil health such as build-up of SOM, N, P and K. Incorporation and subsequent decomposition allows the cycling of almost all the nutrients in the residue to the soil. It also alters the soil environment positively, influencing the microbial population and their activity in soil. Mulching of crop residues on soil surface without incorporation is yet another alternative for residue management. Mulching protects the soil against wind and water erosion and favourably modifies soil temperature. But large volumes of residues retained on the soil surface usually interfere with working of machinery and often affects timely sowing of succeeding crop. Farmers usually follow surface mulching as part of conservation agriculture practices. Composting of residues is an alternate option to recycle the nutrients contained in it and it brings the much-needed organic matter to the soil. Vermicomposting is a green technology to bio-convert crop residues into nutrient-rich organic fertilizers provided the residues are mixed with cow dung in appropriate ratio. Co - composting is a technology for composting organic materials with wider C: N ratio. Nitrogen rich substrates are added to such sources to facilitate better composting. Ligno cellulolytic fungi are also effective in composting residues to nutritionally rich manure. Crop residues are not wastes, but valuable carbon inputs. Mismanagement of crop residues including burning should be strictly avoided. Enriching these carbonaceous inputs and recycling to soil will maintain soil health and sustain crop production in the long run. Indian soils being depleted of SOC, bringing them back to their original carbon carrying capacity assumes greater significance and for this, crop residues have a very important role to play.

Keywords: *Crop Residue, Soil, Organic Carbon*

Biogeochemistry of soils of fresh water swamps in high altitude region, Southern India

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Wetland ecosystems play a key role in maintaining water quality, as they acts as natural filters of earth. Swamps are one among wetlands. Experiments were conducted using ten soil samples each taken from different spots of swamp soils and respective upland soils of three different ecosystems, which belongs to undisturbed, moderately disturbed and highly disturbed ecosystems. They are forest swamp (mixed vegetation of shola and Wattle), grassland swamp and agricultural swamp respectively. The swamps were predominantly covered by rushes *Juncus glocus* and little *Cyprus spp.* The study area is at Nilgiris district of Tamil Nadu. Analysis of enzymatic activities is only one way to measure the ecosystem status of soils as they have been reported as useful soil quality indicators due to their relationship with soil biology. Dehydrogenase, urease, acid phosphatase (phosphomonoesterse) was the enzymes under study. Soil was found to be acidic (3-5). On examination the enzyme activity was found higher in swamps than uplands. The dehydrogenase activity recorded in forest swamp soil was with average of 21.82 µg g^{-1} $day^{-1}$and in upland with average of 14.55 µg g^{-1} day^{-1} .In agricultural swamps with average of 19.18 µg g^{-1} day-and in its upland with average of 11.26 µg g^{-1} day. The grassland swamp, with average of 69.02 µg/g/day and its upland with average of 61.12 µg/g/day. The urease activities in forest swamp with average of 58.49 µg g^{-1} hr^{-1} and the upland with average of 52.47 µg g^{-1} hr^{-1}. In agriculture, swamp soil with average of 44.3 µg g^{-1} hr^{-1} and its upland with average of 37.4 µg g^{-1} hr^{-1} in grassland swamp with average of 62.37 µg/g/hr, and its upland with average of 50.76 µg/g/hr. The forest swamp recorded the phosphatase activity with average of 176.7 µg g^{-1} hr^{-1} in swamp and upland with average of 165.1 µg g^{-1} hr^{-1}. In agricultural swamp soil the phosphatase activity with average of 126.4 µg g^{-1} hr^{-1} and in its upland the activity with average of 120.3 µg g^{-1} hr^{-1}. Grassland samples with average of 280.0 µg/g/hr in swamp and upland with average of 165.1 µg/g/hr. lower activity in agricultural upland can be related to higher rate of farming practice with inorganic matters than organic matters. The other two ecosystems have litter fall and its persistence for organic matter content.

Keywords: *Soil enzyme activity, swamps, high altitude region, fresh water ecosystem*

Integrated Nutrient Management: A Smart Way to Improve the Soil Physical and Bio-Chemical Properties and productivity of Sugarcane

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Sugarcane is an important crop of India and is an important agricultural commercial cash crop and grown on 4.5 percent of the total cropped area of country. During 2018-19 it was estimated at a record 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 period over fairly long period is the need of the hour. Integrated nutrient management sustain soil fertility and provides a sound basis for crop production and its improved 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 10 to 15 percent and 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.

Keywords: *INM, Bio-fertilizers, soil fertility, sugarcane, etc.*

Effect of Organic Manures in Long Term Nutrient Management System on Yield, Quality and Soil Health in Finger Millet

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The high input agriculture has led to self-sufficiency in food grains but it has posed several new challenges. Continuous use of chemical fertilizers is leading to reduction in the crop yield and resulted in imbalance of nutrients in the soil, which has adverse effects on soil health. However, it is now realized that in fields under intensive monoculture which receive heavy applications of chemical fertilizers alone, there is a slow decline in productivity. In this endeavour use of organic manures provide a good substrate for the growth of microorganisms and maintain a favourable nutritional balance and soil physical properties will help to improve physico-chemical properties of the soils. Keeping in view of sustained crop yields as well as soil health, a long term experiment is being conducted at Agricultural Research Station, Vizianagaram for the past six years from 2014 during *Kharif* season to study the effect of use of organic source of nutrients in comparison with conventional method on soil health, Yield and quality of finger millet crop. The organic inputs were supplied in the form of green manure (sunhemp), farmyard manure, neem cake and biofertilizers (*Azospirillum* and *PSB*). The results of the mean pooled data showed that even after a period of six years the conventional (Inorganic) method of cultivation of finger millet showed 14.40 % higher grain yields when compared to organic method of cultivation. During the initial years the difference in the yields was around 24% and gradually it is in the decreasing trend which may take few more years be at par with the conventional method of cultivation. Among the physicochemical properties, the organic carbon % has increased by 0.04% in organic treated plot (0.46%) compared to the initial value (0.42%) which could be attributed to the continuous application FYM, Neemcake, and subsequently incorporation of green manure (sunhemp). Whereas the soil available nitrogen, phosphorus and potassium was found high in organic plot but there is no significant difference between the two treatments. The soil available Zn and Fe was found significantly high in the treatment of organic plot compared to the conventional plot and no significant difference was found in soil available Mn and Cu among both the treatments. Moreover, the plant nutrient N content (1.59%) was found highest in the organic treated plot when compared to the conventional method (1.30%) whereas the Phosphorus and Potassium content was found highest in the conventional method even after 6 consecutive years. It was found that total anti-oxidant activity and total phenol content was found highest in inorganic grain whereas Total sugar, Protein content and Tannin content were found highest in organic grain. Continuous use of inorganic fertilizers under intensive cropping system has caused wide spread deficiency of macro and micronutrients in soil. Keeping in view of sustained crop yields as well as soil health, a long term experiment was being conducted at Agricultural Research Station, Vizianagaram for six years from 2014 to 2019 during *Kharif* season to study the effect of use of organic source of nutrients in comparison with conventional method on soil health,

Yield and quality of finger millet crop. The organic inputs were supplied in the form of green manure (sunhemp), farmyard manure, neem cake and biofertilizers (*Azospirillum* and Phosphorus Solubilizing Bacteria). The results of the mean pooled over a period of six years revealed that grain and straw yields of conventional plot (29.1 q/ha and 82.3 q/ha) are significantly higher than organic plot (24.4 q/ha and 73.5 q/ha). The yield contributing characters were also found highest in conventional plot compared to organic plot. The soil available nitrogen, potassium and zinc were found significantly high in organic plot (234 kg/ha,320 kg/ha and 2.15ppm) compared to conventional plot (214.2kg/ha, 290.4 kg/ha and 1.07ppm). Whereas the uptake of plant nitrogen and potassium uptake was significantly high in conventional plot (63.1 kg/ah and 41.7 kg/ha) compared to organic plot (57.4 kg/ha and 35.9 kg/ha).

Keywords: *Finger millet, Organic, Conventional, yield, soil fertility and nutrient uptake*

Tillering and number of millable canes pattern influenced by different fertility levels and variety in sugarcane

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A field experiment was conducted at sugarcane research station, Muzaffarnagar, to find out the fertility levels to newly release variety of sugarcane during spring season 2015-16 to 2017-18. The soil of experimental field was sandy loam in reaction neutral (pH 7.8) having 0.55% organic carbon, low in available phosphorus and medium in available potassium. The treatments consists of three fertility levels (N1-75% of recommended dose of NPK , N2-100% of recommended dose of NPK and N3-125% of recommended dose of NPK) and three sugarcane variety (V1- CoS 03251 early, V2-Cos 08272 early and V3- CoS 08279 mid- late) in factorial randomized block design with three replications. The recommended dose of NPK (180:80:60) was applied during crop raising. Significantly higher tillers (182863/ha) and number of millable canes (149682/ha) were produced with sugarcane variety CoS 08272 followed by CoS 08279 (176354)and (144997) per hectare, respectively . In case of fertility levels, significantly higher tillers (186399/ha), number of millable canes (156682/ha) were recorded with N3 treatment-125% of recommended dose of NPK over N1-75% of recommended dose of NPK and N2-100% of recommended dose of NPK. In respect of juice quality CoS 03251 gave higher CCS% followed by CoS 08272 over CoS 08279 .The CCS% was decreased with every increasing levels of fertility.

Keywords: *sugarcane, variety, tillers, number of millable canes and quality*

Smoke Derived Compound for Plant Growth and Soil Health

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For the effective plant growth traditionally, fertilizers and pesticides have been used. In recent years, smoke residues and smoke water have been extensively used in agricultural cultivation for the crop growth and for maintaining good soil health. In the past, farmers used to fire the land to control the weed but germination of some plants were found to faster than normal lands. This emphasized the idea of using smoke water in cultivation practices. Karikinolide, the compound found in the smoke water or smoke residues was found to be the main reason for the germination of plants and for the healthier growth. In addition, flowering and fruiting of crops was also achieved by the karikins found in smoke which functions as potential new plant growth regulators. Mainly in drought and in arid condition, smoke derived water helps in plant germination and enhances the growth of the plant. As the smoke derived compounds fasten the plant growth, it also functions as an effective fertilizer, weedicide and herbicide. The usage of inorganic fertilizers, weedicides and herbicides was lessened to the lower extent; smoke derived compounds can be used as a feasible technology for organic farming. This technology also lessens the harmful effect as caused by the inorganic fertilizers and chemicals. For resource poor farmers in developing nations, the smoke water in plant growth promotes a feasible technology for farmers. Very low concentrations of smoke-water or solution are effective in promoting germination and post-germination growth. Thus, early harvesting and increasing the productivity of crops using smoke-technology may be possible. Here we review the potential uses of smoke technology in agriculture and horticulture.

Keywords: *smoke, karikinolide, karikins, organic, health*

Integrated Nutrient Management *vs* Organic Farming: Lessons from Permanent Manurial Trials

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Consistent use of chemical fertilizers and manures in soil alters the physical, chemical and biological properties of the soil. The Permanent Manurial Trials- (tall and dwarf) and the AICRP on Long term fertilizer experiment have been laid out at RARS, Pattambi with the main objective of studying the effect of continuous application of plant nutrients (NPK) in organic and inorganic forms and in combinations on sustainable production in the rice-rice cropping sequence. The PMT consists of 8 treatments while the LTFE consists of 12 treatments. In PMT, the organic nutrient management (T_1) wherein whole of the mineral N was applied as cattle manure and Integrated Nutrient Management (INM) practice (T_5) where 50 per cent N was substituted by cattle manure were equally superior in growth and productivity to other treatments. Treatment T_5 (45 kg N ha^{-1} as cattle manure + $N:P_2O_5:K_2O$ 45:45:45 kg ha^{-1}) was found to be significantly superior with respect to the soil biological properties including dehydrogenase activity and microbial biomass carbon. The physiological properties of the plant like stomatal conductance and photosynthetic rate, yield attributes such as panicle length, number of panicles per plant and number of filled grains corroborated the trend in yield. The available primary nutrient status of the post-harvest soil was higher in T_8, the fertilizer applied plot and substitution of 50 per cent mineral N by organic manures improved the available nutrient status suggesting the synergistic role of organic manures. In LTFE, the integrated nutrient package T_8 had significantly higher dehydrogenase activity and microbial biomass carbon in post-harvest soil which was positively reflected on yield and yield attributes. Application of FYM had beneficial role over green manures towards organic carbon build up in soil. In LTFE with 20 years history, it was seen that all the carbon pools (active, slow and passive) contributed towards yield whereas in PMT, with 44 years history, it was the slow pool of carbon that showed higher correlation with crop yield. Data on analysis of different carbon pools revealed that slow pool is the most predominant yield determining pool in the long run. Thus, the percentage contribution of different carbon pools towards total soil organic carbon in paddy soil of the present work can be rated as: passive (54%) > slow (36%) > active (10%). An incubation study was conducted at four different temperature regimes (15, 25, 35 and 45^{0}C) using the soil collected from the plots of LTFE as well as PMT. The values on activation energy and the rate constants provided a good insight on decomposability of organic matter and the pace of mineralization in soil. Thermal stability studies indicated that the rate of reaction decreases with increase in temperature indicating exhaustion of labile pools available for microbial decomposition. Q_{10} values were also lesser than 1 in both the experiments. Treatments with inorganics recorded lowest activation energies indicating the instability of even recalcitrant or passive pools. The study fortifies INM as a stable practice for sequestering soil organic carbon and crop productivity in the context of rising temperature scenario.

Keywords: *INM, organic farming, permanent manurial trial*

Effect of Tillage Practices and Mustard based Cropping Systems on Soil Quality in Drylands

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Tillage is the agricultural preparation of soil by mechanical agitation of various types, such as digging, stirring, and overturning. Tillage systems can have a major effect on the physical, chemical, and biological properties of soils. Tillage systems affect soil microbial biomass and the activities of enzymes which are potential indicators of changes in soil environment. Generally**,** Conventional tillage aims at reversing and stirring a deep layer of soil; incorporating and destroying plant debris; exposing soil pests to sunshine for control; lump breaking and ground levelling. This preparation is composed primarily of harrowing for removing the residues of previous crop. Long term conventional tillage causes a rapid loss of soil organic carbon (SOM) content, a decrease of soil biological activity and impairment of physical properties over time. However, conservation tillage practices featuring residue cover and reduced soil disturbance have been shown to increase the soil organic matter and is universally recognized. When compared with conventional ploughing, minimum tillage improved the soil pore system by increasing the storage pores (0.5–50 mm) and the amount of the elongated transmission pores (50–500 mm). Conventional tillage have lowest increase of field capacity from the first year value, when compared with other types of tillage practices. Conservation tillage have been established as a technique that increases soil organic carbon.

Keywords: *Conventional tillage, Microbial biomass, Minimum tillage, Soil organic carbon*

Impact of Land Use System and Seasonal Variations on Aggregate Associated Soil Carbon in Outer Himalayas

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Anthropogenic land and environmental degradation have been a major global issue during the twentieth century and in twenty-first century as well. Improper soil management, removal of organic matter from land without replenishing it back through crop cover, intensive tillage, atmospheric pollution, and desertification has resulted in deterioration of soil quality, a fundamental component of ecological sustainability. The Soil acts as the terrestrial C pool and land use is a vital component that determines the Soil organic carbon (SOC) storage and aggregate stability. Soil contains an important pool of active carbon that plays a major role in the global carbon cycle. Agricultural intensification without sustainable proper land use system and management practices, like cover cropping and reduced tillage have led to increased rates of soil organic matter mineralization resulting in poor soil health. Sustaining soil organic matter is, therefore, extremely important for maintaining soil quality in the region. Sustainability of agricultural systems is dependent on soil organic carbon dynamics. Although these land use conversions are necessary to feed the growing population, but they have a definite impact on soil health. Even different seasonal variations such as temperature, rainfall, moisture regimes are having direct impact on aggregate stability. Few ill-managed land use systems can increase the soil erosion rate whereas land use system comprising of cover crops and leguminous species can reduce the soil and nutrient loss. The effect of land use cover on changes in carbon concentration and stocks in a watershed of Sikkim Himalayas showed that below ground, bio-mass in the cardamom based agro-forestry contributed more than (37 %) of total carbon storage compared to that in temperate natural dense forest.) studied whether ten years of organic or conventional management generated difference in biological active SOM pool. Similarly, the decrease in organic carbon content with increase in soil depth. The fragile ecosystems of the Shivalik region, situated in the outer Himalayas and extending over a length of 2400 km along northwestern India, face serious problems of soil erosion primarily due to deforestation, incompatible land use changes, and soil fertility decline. The SOC and aggregate stability have been reported to vary as a function of land use in northwestern India and has been declining due to lack of proper soil management practices and different land use systems. In- organic carbon could be a major contributor to total carbon in water deficit conditions which prevail for most part of the year in these foothills.

Keywords: *Ecological sustainability, Aggregate stability, Soil fertility, Organic carbon, Land use system, Moisture regimes*

Soil Carbon Losses through Erosion as influenced by Conservation Agricultural Practices

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Soil erosion is major problem in the Shivaliks resulting in wide-scale land degradation in the region. Poor management practices in agricultural fields contributes immensely to soil losses from these lands. It is hypothesized that large amounts of carbon may also be lost along with the soil. A study was, therefore, conducted to assess the impact of conservation agricultural practices on soil carbon losses 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 upto 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 losses 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.

Keywords: *Conservation agriculture, tillage, erosion, carbon*

Soil health, Organic Farming and Nutrient Management For Sustainable Productivity

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For many years, land managers and soil scientists have sought to optimize "soil health," or the capacity of a given soil to perform certain functions (Brady and Weil, 2008). To a farmer, a "high quality soil" is one that has sufficient fertility to support profitable production of the farm's chosen mix of crops and livestock, and sufficient stability to sustain production over the long term. In ancient times, farmers used organic wastes for increasing fertility of the soil. Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, genetically modified organisms and livestock food additives. Organic farming is one way to promote either self-sufficiency or food security. But later on, the use of fertilizers started that increase the production but also destroys the structure of the soil due to its use in large amount by the farmer. Therefore the concept of Soil nutrient management introduced. Soil nutrient management is defined by the USDA as managing the application of commercial fertilizers, manure, amendments, and organic by-products to agricultural landscapes as a source of plant nutrients. A common framework for approaching nutrient management is known as the "Four Rs": Right amount - the proper rate of application, right source - applying the proper type, right placement - using the appropriate method for application, right timing - applying at the correct time in the lifecycle of the system.

Keywords: *Soil health, high quality soil, organic Farming, nutrient management.*

Major Sources and Role of Organic Manures In The Enhancing of Soil Fertility Level under Organic Farming System

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Using crop rotations, green manures, biofertilizer and managing crop residues are the major sources of managing soil fertility level and sustainable crop production. A system where different plants are grown in a recurring defined sequence is known as crop rotation. Incorporating leguminous crops and cash crops under crop rotations is the main mechanism for nutrient supply within organic system. Modulating crops fixes different amount of nitrogen fixed in tropical and sub-tropical (100 kg N/ha/year) and temperate regions (200 kg N/ha/year). The architectural characteristics of the root systems of different crops included in the rotation also influence soil physical components like soil structure. Indirectly, timely and use of different cultivation practices and applications of organic manures at different points in the rotation influence soil structure. Crop rotations are the basic means of managing weeds, pests and diseases in organic farming. Several soil fertility-related factors may contribute to manage the soil borne diseases, including soil increased soil microbial activity, leading to increased competition, parasitism and predation in the rhizosphere. Crop rotations improve the potential for cultural management of pests and disease. Soil fertility management can also affect the susceptibility of crops to pests and diseases. Crops like dhaincha, sesbania, sunnhemp, cowpea, urdbean, mungbean, cluster bean, berseem etc., are being grown in India for green manure since time immemorial as a catch/ cover/ forage crop and contributes about 60-200 kg N/ha in turn-up in the soil between 45 to 60 days at the favourable condition of soil. Biofertilizers are microbial inoculants which contains live cells of efficient nitrogen fixing microorganisms which fix atmospheric nitrogen either symbiotically host plant or free living as well as phosphate solubilizing microorganisms. Rhizobium, *Azotobacter, Azospirillum, Acetobacter*, Blue Green Algae, Azolla and Phosphate solubilizing microorganisms are most commonly used biofertilizers in India for nitrogen or phosphorus nutrition. Incorporation of crop residues is also another important source of nutrients in subsequent crops. A different quantity of N, P, K and other nutrients removed from the soil is returned to the soil depending on the crop species concerned. The quantity and quality of crop residues will clearly influence the build-up of soil organic matter. The inclusion of crops with a diverse range of C:N ratios can help to conserve N within the system. Animal manures are the most common amendments applied to the soil. Organic manures produced from non-organic farms may be brought into the holding but there are restrictions. The quantity of nutrients in manures depends upon the types of animal, feed composition, quality and quantity of bedding material, length of storage and storage conditions. Developments of several compost production technologies like vermicomposting, phosphor-composting, N-enriched phosphor-composting etc. improved the quality of composts through enrichment with nutrient bearing miners and other additives and promote the activity of beneficial macro- and micro-flora in soil. Oil cakes of non-edible types like castor, neem and keranji as well as edible cakes like groundnut and mustard are widely used in India as organic manures

due to their high N, P and K content. Animals wastes like bone meal, fish meals etc. are also rich in nutrients and are often used in organic farming. In order to balance the off take of specific nutrients, there are a number of mineral nutrient sources acceptable in organic systems although their use is permitted only where it can be demonstrated to the certifying body. Amendments include rock phosphate, rock potassium, magnesium rock, potassium sulphate, basic slag, gypsum (calcium sulphate), Epsom salt (magnesium sulphate), calcitic lime, dolomite lime etc. Rock phosphate release nutrients slowly over a period of years and thus, their use is planned to build soil fertility in long run. Lime is used to maintain pH level of the soil. The supply and management of N is more complex in organic than in conventional farming. Synchronizing the availability of N mineralized from manures and crop residues with crop demand is the major challenge of N management in organic farming. Most of the organic nutrient management practices are site-specific and crop-specific. Therefore, more sincere research efforts are needed to develop and fine tune the nutrient management technologies to suite different agro-ecological and site-specific requirements.

Keywords: *Organic manures, Rhizobium, Azotobacter, Azospirillum, Acetobacter, Organic farming system*

Management of Organic Manures and Bio-Agents for Organic Cultivation of Sugarcane

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Sugarcane, which plays a pivotal role in the agro-industrial economy of the country particularly for sugar and jaggery production after cotton textiles, is being cultivated in India on a large scale. Molasses, press mud and bagasse are important by-product of sugar industry. Molasses is used for alcohol production, while press mud is used in the soil as an organic manure. Bagasse is used to generate electricity in cogeneration plant and number of other works. Sugarcane is cultivated in tropical as well as sub-tropical crops as a long duration crop, requiring high amount of water and nutrients. The crop requires 750–1200 mm of rainfall/water during its entire growth period for the optimum yield. Depending upon the variety and time of planting, the crop takes about 10 to 18 months to mature in different agro-climatic zones. Two shallow ploughings should be done for making the soil loose and fluffy. The compost/vermicompost may be applied @ 6.75 tonnes/ha with 100 kg rock phosphate and 4 kg Phosphate solubilizing bacteria (PSB) with the first ploughing. Ridges and furrows should be made in the N-S direction for sufficient solar-harvesting. Application of 200 kg Neem leaf/seed manure and 500 kg concentrated manure in the furrows at the time of planting ensures good germination and yield. Application of different biofertilizers such as *Azotobacter, Pseudomonas, Azospirillum, Trichoderma, Gliocladium* sp. *Arbuscular mycorrhiza* (AM) fungi and number of seaweeds results in improving physical properties of soil and yield enhancement. Farmyard manure (FYM) or press mud should be applied at 80 t/ha either before last ploughing or in the furrows before planting. Freshly cut seed setts should be treated by dipping in cow dung and cow urine slurry for 10–15 minutes, followed by dipping in *Azotobacter* and *Azospirillum* solution for 30 minutes. Two budded setts from 8-10 months old disease-free nursery crop should be planted by adopting 120cm spacing in paired row by trench planting method. Hand hoeing and weeding can be done at 30, 60 and 90 days after planting. Apply 5 kg/ha each of *Azospirillum* and *Phosphobacteria*, respectively on 30 and 60 days after planting of sugarcane, by mixing it thoroughly with FYM @ 500 kg/ha. Give a light earthing up and irrigate immediately. Remove the dried and senescent leaves at 5th and 7th month and apply them as mulch in alternate furrows. One ratoon after the plant crop is a common practice for organic farming. Residue should not be burned after the harvest as the crop residue is converted into compost by decomposer which can be used in the same field. Red rot and wilt can be managed by sett treatment with PGPR/Trichoderma followed by soil application of these formulated in talc/press mud. For protection from red rot, fungal bio agents viz., Chaetomium, Trichoderma and bacterial antagonists individually and the combination of Pseudomonas fluorescens and Bacillus species have been found to be effective. Further, press mud formulation of Trichoderma was found effective against wilt and seedling rot caused by Pythium spp. Borers and white woolly aphids are crucial insect pests of sugarcane. The release of *Trichogramma chilonis* @ 50,000 per ha, 45 days after planting, ensures effective biological control of early shoot borer. Staple cards pasted with 0.2 cc eggs of *Trichogramma chilonis* parasite in the field @ 25 cards/ha equally distributed in

25 places once in 15 days when the crop is 4-11 months of old. Alternatively, set up pheromone traps in the field @ 25 number /ha spaced at 20 meters apart when the crop is 5 months old, trap and kill the male moths of internode borer. Replace the pheromone vials in the traps in 7th and 9th months. Inundated release of Chrysoperla @ 2,500 to 5,000 eggs/ha or mixing of 2 kg custard apple leaves, 2 kg Pongamia leaves and 2 kg Ipomoea leaves with 500 ml Neem oil in an earthen pot along with 8–10 lit res of hot water and 200 g soap powder and the solution is mixed properly in 15 litres of water to be used as a foliar spray for management of white wooly aphids. Similarly, mixture of onions in cow urine and sour buttermilk are used as effective spray for the control of wooly aphids.

Keywords: *Organic manures, Bioagents, Azotobacter, Pseudomonas, Azospirillum, Trichoderma*

Effect of Zinc Sources and Method of Application on Zinc uptake and Use Efficiency in Brinjal (*Solanum melangena* L.)

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A field experiment was conducted during kharif, 2018 at vegetable block, college of Horticulture, UHS, Bagalkot to study the effect of various sources of zinc on zinc uptake and use efficiency of brinjal. The experiment was laid out in Randomized Block Design with 8 treatments and 3 replications. Total plant zinc uptake in nano zinc fertilizer treatment was on par with conventional zinc sulphate fertilizer and found superior over control (8.41 mg/plant). Zinc uptake efficiency of nano fertilizers was significantly higher (0.12-0.13) compared to conventional fertilizer (0.06-0.07) and control (0.09). Crop recovery efficiency for nano zinc sulphate applied through soil (0.87) or soil + foliar (0.84) or foliar alone (0.81) showed significantly higher recovery efficiency compared to conventional zinc sulphate. Though quantity of nano zinc applied is just 3.5 per cent of the conventional zinc but still then they could be able to meet the plant demand and maintain soil and plant zinc at optimum level.

Keywords: *Nano zinc sulphate, nano zinc oxide, conventional zinc sulphate, crop recovery efficiency and zinc uptake efficiency*

Sustainable Soil Health Management in Rainfed Fruit Production Under Changing Climate Scenario in Shivaliks Foothills of Jammu And Kashmir, India

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Agricultural situation in the India changing in the lot of introduced green revolution technology. In addition to this, due to the inauspicious climatic conditions there are many changes happening in agriculture from the past few years. The conservation techniques for, production and livelihood security in rainfed area of the horticulture can be profitably mitigate by suitable exploitation of available research results and dedicated implementation. The soil and water are the two most important natural resources for the sustainability of fruit production in changing climate scenario in any region. However, their organic matter status and soil loss depletion of alarming rates is being felt in any region. The rainfed region depends mostly on rainfall for crop and fruit production. In Jammu and Kashmir, about 70.0 to 80.0 per cent annual rainfall occurs during three months July to September as a result of the South-West monsoon. In May to June and October to November are the driest months and crops facing scarcity of water. Climate change cause abiotic pressure in the living system which otherwise referred to as the negative impact of non-living factors on the living organisms in a precise environment. The abiotic stress is naturally occurring factors such as low or high rainfall, extremes in temperature, intense sunlight or wind that may cause harm to the grain and pulse crop in the area affected. The soil health and water management various practices can be improved the soil quality through mulches by in-situ and an ex-situ technique is successful. The rainwater is collected and after the supplementary irrigation of horticulture and vegetables crops are improved the better quality. There is only fruit cultivation in the Shivaliks areas of Jammu and Kashmir successfully grown and the farmer benefit in these areas. Abiotic stress affects organisms dependent on environmental factors. Abiotic stress is the most harmful factor concerning the growth and productivity of horticultural crops. The present paper highlights the assessment of soil and water status and strategies to mitigate the adverse effect of abiotic stress on fruit production crops in rainfed areas.

Keywords: *Soil health, conservation technique, natural resources and Climate change*

Status of Major Nutrients of Bhaderwah orchard under temperate condition

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Soil fertility evaluation of an area or region is most basic decision-making tool for the sustainable soil nutrient management. An investigation was conducted to ascertain the properties of the soils and available nutrients of Regional Horticultural Research Sub-station, Bhaderwah. Soil properties and available nutrients *i.e.* pH, electric conductivity (EC), organic carbon (OC) and available nitrogen, phosphorus and potassium in soils of various blocks of the research farm of Bhaderwah, district Doda. During study, it was observed that the dissimilar fruit and agriculture block of the soil properties and available nutrients was more in the variation of surface soils (0-15 cm). Soil properties and available N, phosphorus and K parameters ranged between pH (5.50 -6.42), EC (0.115- 0.166 dSm^{-1}), Organic Carbon (4.12-5.64 g kg^{-1}), available N (198.56 - 254.45 kg ha^{-1}), available phosphorus (11.45-16.50 kg ha^{-1}) and available K (125.26- 165.00 kg ha^{-1}) in different fruit and agriculture crops block of the research farm. The fertilizer recommendation can be done based on determined soil fertility status to economize crop production. Moreover, research farm should develop future research strategy accord with the prepared soil data base.

Keywords: *Chemical properties, Available NPK, Nutrient status, temperate areas and soil*

Impact of Different Land Use Systems on Size Distributions and Aggregates Stability in The Sub-montaneous Zone of Foothill Himalayas

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Soil aggregate stability is an indicator of soil quality. Soil aggregation is important for the resistance of land surface to erosion, and it influence the ability of soils to remain productive. Management influences the properties of the soil through their effect on the organic matter. The present study was conducted to assess the impact of different landuse and management on soil aggregate stability in submontane Jammu, India. Soil samples were collected from five different land use systems viz forest, horticulture, agriculture, pasture and degraded lands from each of the five locations for surface (0-15) and subsurface (15-30) cm of soil depth. Soil aggregate stability was determined by dry and wet sieving methods. Dry sieving was determined without immersion in water and wet sieving was immersion in water respectively. Soil properties such as soil organic carbon (SOC), bulk density (BD) and soil pH were also determined. Average soil organic carbon (SOC) content was observed to be higher in Pasture (6.65 g kg^{-1}) followed by forest (6.50 g kg^{-1}), Horticulture (5.76 g kg^{-1}), agriculture (4.88 g kg^{-1}), and degraded land (4.47 g kg^{-1}). Soil BD was observed significantly higher in degraded land than in other land uses, which was further increasing in deeper soil profiles. Macro aggregates (>2 mm) were abundant (52.52-91.13%) in pasture soils while micro-aggregates (<0.25 mm) were abundant (23.39-35.51%) in agriculture lands. Mean weight diameter (MWD) decreased significantly with immersion in water for soil depth for various land uses indicating that the soils were vulnerable to water erosion. The influence of cultivation was generally expressed by reduced WAS of soil aggregates, hence rendering the soil more vulnerable to crusting and erosion processes. Mean weight diameter (MWD) was dominant in pasture in surface soil whereas subsurface soil was dominant in forest landuse systems. The mean weight diameter from dry structure stability (GMDd) and their corresponding wet Mean weight mean diameter (MWDw) were related significantly (r = 0. 0.999**).The difference in the MWD in dry condition and immersion in water reveals that for degraded land was subject to severe degradation compared to cultivated, agriculture and horticulture soil, while for pasture land was more degraded than forest soil. The vegetation grown soils were of better soil structural quality than degraded land or no scanty vegetation. To preserve good structure thereby reducing soil degradation, long term fallows or other farming practices that ensure maintenance of soil organic matter.

Keywords: *Aggregate stability, size distribution, land use, soil organic matter, soil management*

Moisture Influence on the Soil Microbial Dynamics and Microbial Population

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Soil moisture being a strong determinant of microbial activity exerts dominant control over gaseous and liquid diffusion rates and thus affects oxygen and substrate availability. Increasing soil moisture reduces gaseous diffusion rates, directly affecting microbial physiological status and activities by limiting the supply of the dominant electron acceptors. As the matric potential in soil water decreases, cells must utilize energy to attain osmotic equilibrium with the surrounding solution indirectly reduced their growth and activity. Wetting and drying also affects microbial activity in soil, respiration rate, DHA and microbial community structure. Physiological drought induced by salinity induced osmotic stress results in poor plant growth and low soil microbial activity. Heat evolution from soil without presence of optimum nutrient solution increased with increased moisture, suggesting that dryness inhibits the microbial activity because the heat production of microbes in soil is a direct measurement of the cellular metabolic activity. The relationship between heat evolution and humidity shows direct relationships between moisture and carbon dioxide evolution, dehydrogenase activity and ATP production. The response to soil drying varies widely across organism functional types (e.g., soil fauna, bacteria, fungi) and species. Fungi are generally considered more tolerant than bacteria to soil drying. This is due to their ability to accumulate osmo-regulatory solutes that do not impair metabolism and to their filamentous structure, which allows them to reach and exploit substrates even at very low soil moisture levels, where diffusivity is low. The documented scientific literature converges towards the conclusions that soil moisture affects the microbial population, diversity and their biological and biochemical properties by affecting substrate availability, diffusion of liquids and gases and regulating the osmotic stress faced by soil micro-organisms. The functional relationships between water content or potential and the soil microbial demography appear to be hysterical in case of wetting drying cycles because usually the response time for the microbial characteristics to adapt to an altered soil moisture regime is far from instantaneous. Soil moisture conditions are inherently more dynamic than any other soil characteristic. Therefore, present study was focused on understanding of the microbial characteristics under dynamic moisture conditions together with the biochemical pathways of nutrient availability and transformations, organic matter decomposition and substrate availability that can be help in better manage of soil water and diverse soil microbial resources in agriculture.

Keywords: *Microbial Activity, ATP, Osmotic Equilibrium*

Effect of organic and inorganic sources on nutrient availability and soil physio-chemical properties of apple orchard soil

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A study was carried out at five different location s of district Poonch during three successive years 2017, 2018 and 2019 on 13 year old apple trees to investigate the conjoint efficiency of bio-organics used along with chemical fertilizers on nutrient availability and physio-chemical properties of soil. Conjoint application of Vermicompost, FYM and chemical fertilizers in treatment combination ($N_{50\%}$ +$VC_{37.5\%}$ + $FYM_{12.5\%}$, $P_{65\%}$ + $VC_{30\%}$ + $FYM_{5\%}$ and $K_{65\%}$+VC $_{22.5\%}$+$FYM_{12.5\%}$), resulted significantly maximum porosity (59.85 %), water holding capacity (60.87%), bulk density (0.96%), particle density (2.24 %), organic carbon (1.89%), soil pH (6.81), soil N (401.10 %), P (21.75%), K (413.02%), Fe(63.66ppm), Mn (60.52 ppm), Zn (2.10 ppm) and Cu (3.02 ppm).

Keywords: *Apple, Vermicompost, FYM*

Biofertilizer - A Key Player in Enhancing Soil Fertility and Crop Productivity

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Our dependence on chemical fertilizers and pesticides has encouraged the thriving of industries that are producing life-threatening chemicals and which are not only hazardous for human consumption but can also disturb the ecological balance. Soil management strategies are mainly dependent on inorganic chemical-based fertilizers, which caused a serious threat to human health and environment. The exploitation of beneficial microbes as a biofertilizer has become vital in agriculture for their potential role in food safety and sustainable crop production. The eco-friendly approaches inspire a wide range of application of plant growth promoting rhizobacteria (PGPRs) and many other useful microscopic organisms led to improved nutrient uptake, plant growth and plant tolerance to abiotic and biotic stress. Environmental stresses are becoming a major problem and productivity is declining at an unprecedented rate. Biofertilizers can help solve the problem of feeding an increasing global population at a time when agriculture is facing various environmental stresses. It is important to realize the useful aspects of biofertilizers and implement its application to modern agricultural practices. Bio-fertilizer can be an important component of integrated nutrients management. Microorganisms that are commonly used as bio-fertilizer components include; nitrogen fixers (N-fixer), potassium and phosphorus solubilizers, growth promoting rhizobacteria (PGPRs), endo and ecto mycorrhizal fungi, cyanobacteria and other useful microscopic organisms. The use of bio-fertilizers leads to improved nutrients and water uptake, plant growth and plant tolerance to abiotic and biotic factors. Apart from acting as growth promoting agents, they can provide resistance against pathogens by producing metabolites. These potential biological fertilizers would play a key role in productivity and sustainability of soil and also in protecting the environment as eco-friendly and cost-effective inputs for the farmers. The government is likely to make purchase of bio-fertilizer compulsory for every bag of urea a farmer buys to promote organic nutrients and slash the use of chemical fertilizers.

Keywords: *biofertilizers, PGPRs, mycorrhiza, cyanobacteria*

Estimation of Particulate Matter & its Correlation with Meteorological Parameters in the Ambient Atmosphere of Mahendergarh, Haryana

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The fine particulate matter (PM2.5) problem has appealed much scientific and public attention, due to its effects on human health, visibility, and global climate. The scientists are increasingly concerned about particulate matter pollution caused by respirable suspended particles (PM2.5). Reducing air pollution and mitigating climate change are increasingly being approached in a more integrated way. Air pollution is highly sensitive to meteorology; climate change has the potential to affect air quality by modifying temperatures, wind speeds, humidity, and precipitation, which all affect pollutant formation. In this paper, PM2.5 concentration are estimated and correlated with meteorological parameters (Temperature & Humidity). Particulate matter (PM2.5) samples were collected at the Central University of Haryana sampling site in the Mahendergarh, Haryana. The spatial distribution depicts that the part of the study area has the alarming PM2.5 pollution. The average concentration of particulate matter (PM2.5) during the analysis period was 92.93µg/m3 which exceeds the Annual National Ambient Air Quality Standards for PM2.5 (60µg/m3). The correlation analysis results between PM2.5 concentration and meteorological data showed that PM2.5 concentration was negatively correlated with temperature while positively correlated with humidity. The research suggests that adequate government regulation, public awareness, regional collaboration and industrial compliance are keys to successfully controlling PM2.5 pollution.

Keywords: *Particulate matter (PM2.5), meteorological parameter, spatial distribution*

Impact of Different Land Uses on Soil Characteristics of Chandanwari micro-watershed of district Anantnag

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Chandanwari micro-watershed of Lidder Catchment is situated in southern part of Kashmir Valley. This micro-watershed is located between 34°00'59"N to 34°03'43"N latitude and 75°19'18"E to 75°21'56"E longitude. After traversing the whole Chandanwari area, several aspects like climate, vegetation, and relief were recorded and micro-watershed was selected for study purpose. The samples were taken from selected four different land uses at three depths i.e.; 0-15cm, 15-30cm, 30-45cm. The total area of selected micro-watershed is approximately 8 km² and the elevation of this micro-watershed ranges from 2235 to 2470 meters above mean sea level. In order to assess and investigate soil quality status of study area, a total of 60 surface and sub-surface soil samples were taken, examined and analyzed for physicochemical and biological properties. The pH of the soils is slightly acidic to neutral with highest in agriculture land use (7.18) and lowest in forest land use (5.68). The highest electrical conductivity was recorded in agriculture land use (0.29 dSm^{-1}) and lowest was recorded in fallow land use (0.15dSm^{-1}). Higher concentration of OC (%) was found in forests (1.77) and lower in fallow land (1.09) while as the concentration of $CaCO_3$ (%) was found highest in forests (0.75) and lowest in agriculture land use (0.36). The CEC ($cmol_c\ kg^{-1}$ soil) was almost same in agriculture (25.61) and forest land use (25.63) while as lowest CEC ($cmol_c\ kg^{-1}$ soil) was observed in fallow soils (20.10). The bulk density and particle density between different land use systems did not show much variation. The agriculture land use system had low amount of available nitrogen (222.46 $kgha^{-1}$) while as the highest was recorded in forest land use system (402.68 $kgha^{-1}$). The available phosphorous and potassium was found in medium range in all the four land uses. The highest Sulphur content was found in forest land use with a mean value of 27.50 $kgha^{-1}$ while as the lowest was found in agriculture land use with a mean value of 18.34 kg ha^{-1}.

Keywords: *Catchment, Land use, Land cover, Micro-watershed, Soil quality*

Role of soil nutrients and germplasms conservation: need for soil nutrient indexing for better resource use efficiency

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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 becoming alarmingly needed 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 achievement strongly recommended for precision management of valuable nutrients for greater resource use efficiency.

Land use effects on soil enzymes in high altitude region, The Nilgiris

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Soil enzymes are the dynamic properties and responds fast to management practices. Enzymes play a key role in soil biochemical processes such as decomposition, nutrient release and nutrient conversions. Land and soil use change with different intensities disturbs the biochemical properties such as soil enzymes becomes a reliable indicator of soil health. Investigation was planned to understand the enzyme activities such as dehydrogenate, urease and phosphatise under undisturbed ecosystem of Shola forest, limited disturbed ecosystem of tea plantation and severely disturbed ecosystem of agriculture in the Nilgiri region of Western Ghats. We have collected surface and profile soil samples at three land uses such as Shola forest, tea plantation and agriculture between the elevation of 2000-2200 msl. Surface soil sample collected at 0-30 cm depth and in profile it was upto 60 with 15 cm increment from the surface. Surface soil sample collected randomly at 10 places and profile samples collected three places in each land uses. Soil enzymes of dehydrogenate, urease and phosphatise were estimated from field brought and processed soil samples with standard procedure. It has been estimated that the dehydrogenase activity was 37.7±15.8, 28.4.2±2.90 and 21.2±6.3 µg g^{-1} day^{-1} in Shola forest, tea plantation and agricultural land uses respectively. Urease activity was recorded 95.2±12.5, 52.9±6.99 and 85.9±11.4 µg g^{-1} hr^{-1} in Shola forest, tea plantation and agricultural respectively. Phosphatase enzyme activity in Shola forest, tea plantation and agriculture was 211.7±68.3, 235.5±20.27 and 172.5±51.8 µg g^{-1} hr^{-1} respectively. Highest dehydrogenase and urease activity were recorded in Shola forest might be due to high organic carbon. The highest phosphatase activity was recorded in tea plantations soil. Agricultural soils recorded lower activity of all three enzymes and thqt implies the poor health which might be due to heavy application agrochemicals for their commercial agriculture.

Keywords: *High altitude; land uses; The Nilgiris; soil enzymes*

Studies on combinations of organic sources on productivity of rajmash (bush type) under high hills of Jammu

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Experiment was conducted at Research Farm of Regional Horticultural Research Sub-Station, Bhadarwah of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu on bush type rajmash (*Phaseolus vulgaris* L) to evaluate the different mixture of organic sources. Two years study revealed that maximum yield of 15 q/ ha and yield attributes of rajmash was observed in with the application of 1.25 t/ ha FYM + 1.25 t/ ha vermicompost + 1.25 t/ ha neem cake + 1.25 t/ ha pine needles + biofertilizer + rock phosphate @ 56 kg/ ha followed by the application of 1.25 t/ ha FYM + 1.25 t/ ha vermicompost + 1.25 t/ ha neem cake + 1.25 t/ ha pine needles and seed treatment through tricoderma (4g/kg of seed) + Neem oil (3%) through foliar spray after one month and repeated at 15 days interval over rest of the organic combination. Soil organic carbon content at the completion of experiment varied from 0.83 to 0.86% in all the plots where organic practices were adopted over initial value of 0.81%.

Keywords: *FYM, Vermicompost, Neem cake, Rice straw and Pine Needles.*

Organic pest control approaches against fruit flies towards sustainable productivity in Guava

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An organic integrated pest management strategies were successfully implemented for the effective management of fruit flies in guava in lower gangetic alluvium soil of West Bengal. This research study was implemented in Guava orchard, Horticulture Research Station, Mondouri, BCKV, West Bengal with the aim of developing comprehensive pest management methods for fruit flies. The experiment was performed in a randomized complete block manner with seven treatments, including three replications. Observations are taken in two time intervals of 15 days through pupal recovery method and Neem oil 5% foliar application along with plastic mulching was found to be most effective (6.83), followed by Plastic mulching (10.31) and then, Tillage with Metarhizium anisopliae (11.16). The next least pupal recovery was noticed in Neem oil 5% spray (12.33), followed by Neem cake with tillage (14.66) and Tillage treatment (16.83). The highest recovery was seen in controls (28.99). And for correct pest monitoring pheromone traps and if pest infestation exceeds economic injury levels should follows biopesticides applications in an effective manner.

Keywords: *Pupal recovery, Metarhizium anisopliae, Neem oil, Neem cake, Organic pest management*

Capturing Diversity in Integrated Farming Systems Prevailing in Marginal Households Through Quantitative Farming system typology

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Integrated farming system is a management strategy which ensures optimal utilization of resources within the farming system to maximize productivity and profitability while ensuring sustainability. Quantitative farming system typology is a tool for in-depth farming system analyses and further exploratory studies for detailed characterization. The study area was Southern Coastal Plains Agro-Ecological Unit (AEU) located between 8° 46'48" and 8° 34'12" N latitude; 76° 40'12" and 76° 53'24" E longitude; zero and 72 m above mean sea level of Thiruvananthapuram district, Kerala State, India. The methodological framework of farming system typology utilized in the study comprised of following five steps. First step was to formulate hypothesis on heterogeneity of farm households through focus group discussion with an expert 'design panel' of local stakeholders with good knowledge of study area viz. Agricultural Officers in Department of Agriculture Development and Farmers' Welfare. Second step was to create baseline data of farm households through sample survey. Survey questionnaire was used to interview 200 sample marginal households practicing low input mixed crop-livestock agriculture during kharif 2018-19 i.e. 20 households selected randomly from each of 10 panchayats selected purposively in the study area. Third step was to select from the surveyed data, key quantitative variables characterizing the farm households, through focus group discussion with the same local stakeholders who initially formulated hypotheses. Fourth step was to distribute surveyed farm households among clusters by sequentially using two multivariate statistical techniques namely principal component analysis (PCA) and cluster analysis (CA). Fifth step was to compare the farm types with initial formulated hypothesis to confirm that farm types are conceptually meaningful having explanatory value, thus validating hypothesis while ensuring wider acceptance and usability of the results. Based on 2018-19 survey data, the typology was constructed using the multivariate statistical techniques of principal component analysis and cluster analysis. Results proposed four farm types, stratified on basis of household, labour, land use, livestock, livestock production, income and expense. Type 1 characterized by abundant with small non- ruminant livestock. Type 2 was households with plenty of fruit and vegetables, ample on-farm income and high all farm enterprises production cost. Type 3 was characterized by sizeable land owned, plenty of food grains, and profuse use of farm machinery. Type 4 was households with plenty of fodder, abundant with large ruminant and milch animals. This study clearly demonstrates that using the established typology as a practical framework allows identification of type-specific farm household opportunities and constraints for the targeting of agricultural interventions and innovations, which will be further analyzed in the research-for-development project.

Keywords: *Farming system, Kerala, Resource characterization, Southern coastal plain, Typology, Development*

Training needs Assessment of Castor Growers of Palanpur Taluka of Banaskantha District (Gujarat)

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Castor is one of the important oil seed crop in India, Gujarat state is the largest producer of oil seed crops particularly castor, mustard, and seasamum. Castor crop is mostly cultivated in North Gujarat and Saurashtra region of the state. In North Gujarat it is largely grown in Mahesana and Banaskatha districts of which Banaskatha district was considered to assess the training need of Castor growers. With a view to assess the training need of castor growers study was conducted in Palanpur taluka of the district which was selected randomly. Eighty Castor growers from eight villages were randomly selected for the study. The analysis of the data revealed that majority of the respondents were of middle age, having primary education. Farming along with animal husbandry was the main occupation of majority farmers. Majority of the farmers have tube well for irrigating their lands Farmers were having their annual income. Study further indicated that majority of Castor growers prefer to receive training on diagnosis and control measures of diseases and pests (Rank l and ll, respectively) followed by organic manures and application of manures and fertilizers. Education and social participation were significantly related with training need of Castor growers. Occupation, land holding irrigation facilities and annual income were not-significantly related with training need of Castor growers. Age had negative and highly significant relationship with training need of Castor growers. The major constraints faced by Castor growers were sudden attack of wilt disease followed by sudden attack of sucking pests, Nematodes and unavailability of certified seed. Respondents suggested arranging the training on the subject of plant protection followed by increasing the production of certified seed and developing resistant variety against disease and pests.

Keywords: *capacity building, training needs, castor*

Potentials of Growing Underutilized Fruit Crops in Kashmir for Sustainability and Nutritional Security

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Jammu and Kashmir being endowed with natural advantages of topography and climate with enormous diversity of agro-climatic conditions has immense scope for horticultural development. Horticultural industry in the state made rapid strides during the last few decades. Compared to 1954-55, the area under fruits in the state increased by 16 times and the production has shot up to 60 times. To supply a balanced diet to its huge population is becoming a stupendous task to the scientists and planners of India. Large number of fruits, 647 species belonging to 357 genera remain as underutilized or minor fruits in India. Attempts to increase global food security face a number of complex and interlinking challenges. The need to provide food for (and also actually to feed) nine billion people will require an intensification of farming at one end of the scale, but local issues, such as nutritional and dietary diversity and the loss of traditional diets, will increasingly demand attention if any long-term form of food security is to be achieved. Underutilized plant species have local or regional importance, but generally lack national recognition and appreciation. The under-utilized crops are the plant species that are traditionally used for their food, fiber, fodder, oil or medicinal properties. However, those species have under-exploited potential to ensure food security, nutrition, health, income generation and environmental services. In J & K crops like pomegranate kiwi, quince, grapes, hazelnut, chestnut pistachionut, pecanut, persimmon, fig and loquat are underutilized because of poor management and market interventions. Minor crop species play a very important role for allowing the the rural community by reducing poverty. It is not only poor people who benefit from underutilized species. All people benefit in terms of diet, income, better maintenance of agro-ecosystems and use of marginal lands for cultural identity. There are large areas of marginal and wastelands, which are not suitable for cultivation of other species, either due to poor quality soil or lack of water resources. Such lands are suitable for underutilized fruit crops which are in good demand but these crops are not very popular among the farmers. Most of these less known fruit trees establish through natural regeneration of seeds, grow slowly without any nutrition, start bearing fruits after a long period and produce fruits of inferior quality. Hence these species have remained neglected without any commercial importance. As some of these species are tolerant to harsh agro-climatic conditions, they have excellent potential for establishment on marginal and wastelands. Fortunately, during the last 1-2 decades, suitable technologies have also been developed to improve the productivity of these crops. However, there is further need to set up field demonstrations to provide first hand exposure to the farmers for popularizing these species in the field.

Keywords: *Underutilized crops, potentials, opportunities, nutritional security, sustainability*

Yield of different Varieties of Sugarcane

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Krishi Vigyan Kendra (ICAR-IIVR),Sargatia, Seorahi, Kushinagar assessed the yield performance of different sugarcane varietiesat KVK farm in district Kushinagar U.P.. in the year 2013 to 2015. Under investigation varieties like CoSe 5451, CoSe 96436, UP 5125, Co 86032 and CoSe 1434 have been taken. Results shows that planting of sugarcane in paired row in trenches variety Co 86032 gave higher yield i.e.625.35q/ha. in comparison to rest other varieties. The yield of other varieties respectively is 605.55, 515.45, 525.35 and 505.25 as UP 5125, CoSe 5451, CoSe 1434 and CoSe 96436. Sowing of sugarcane in paired row save seed, fertilizer, fuels, water and man power and increases the productivity of crop. The weight of per sugarcane average is maximum recorded in the variety Co 86032 i.e. 1.30 to 1.38 kg. The plant height, softness, nutrient use efficiency, water use efficiency and weight in per trolly of sugarcane average is maximum recorded in the variety Co 86032.

Keywords: *Sugarcane, yield, varieties*

Agricultural Diversification: Way of Increasing Sustainability of Agricultural Production System

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Agricultural diversification can involve movement of resources from low-value commodities to high-value ones. It focuses mainly on horticultural, dairy, poultry and fisheries sectors. Farming continues to be the major source of food, fiber, oil, nutrition, income and employment for the most of the rural population in India. In the past five decades or so, increasing agricultural production and ensuring food security was the main concern for agricultural development. To the great satisfaction, Indian farmers with the help of agricultural scientists and policy makers could achieve that by bringing 'Green Revolution' and 'Rainbow Revolution'. This established India as the self-sufficient country in agriculture and face-lifting of Indian agriculture in world map was made possible. In India, the agricultural sector is dominated by large number of small and marginal scale farmers with small farm holdings and rain-fed food production systems that are facing increasing challenges from land degradation and declining soil fertility. With the introduction of scientific and recent agricultural technologies there is a continuous way of diversified agriculture. The changes in cropping patterns, however, are the outcome of the interactive effect of many factors such as (a) Resource related factors mainly irrigation, rainfall and soil health (b) Technology related factors mainly seed, fertilizer, water use, marketing, storage and post-harvest processing (c) Household related factors mainly food and fodder self-sufficiency requirement as well as investment capacity of the farmers (d) Price related factors covering output and input prices, trade and other economic policies that affect these prices (e) Institutional and infrastructure related factors covering farm size and tenancy issues, research, extension and regulatory policies of the government. Urgent needs to adopt diversified agriculture for increasing sustainability of agricultural production.

Keywords: *Resource, diversification, sustainability.*

Evaluation of Blackgram Varieties Under Rainfed Conditions of Chamarajanagar District, Karnataka

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A field experiment entitled evaluation of blackgram varieties under rainfed condition of Chamarajanagar district was conducted during pre-kharif 2018 and 2019 by Krishi Vigyan Kendra, Chamarajanagar, Karnataka. The varieties included in the test were LBG 625 (Check), LBG 791 and KU14-8. The incidence of yellow mosaic virus was significantly less with LBG 791 (1.24 %) as compared to LBG 625 (31.3 %) and was on par with KU14-8 (1.47 %). Among growth parameters, more number of branches were observed with LBG-791 (4.92) as compared to LBG-625 (4.31) and KU-14-8 (1.68). Whereas the maximum plant height was observed with LBG-625 (49.3 cm) as compared to LBG-791(36.6 cm) and KU 14-8 (28.6 cm). The yield parameters viz. number of pods/plant, pod length, No. of seeds per pod and 100 seed weight were significantly more with LBG 791 (41.6, 5.5 cm, 7.65 and 5.47g, respectively) as compared to KU 14-8 (36.8, 5.4 cm, 7.61 and 5.19g, respectively) and LBG-625 (35.9, 4.9 cm, 6.4, 5.06g, respectively). However, the grain yield and harvest Index were significantly higher with LBG 791(727 kg/ha and 0.23, respectively) as compared to KU 14-8 (627 kg/ha and 0.22, respectively) and LBG-625 (363 kg/ha and 0.16, respectively).The highest gross returns and B:C Ratio of Rs.36,302/ha and 1.41, respectively were realized with LBG 791 as compared to KU 14-8 (Rs.31280/ha and 1.41, respectively) and LBG 625 (Rs. 16346/ha and 0.74, respectively).

Agricultural diversification through processing and value addition for livelihood security of rural youth

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Youth are expected to play a vital role in the much-anticipated transformation of agriculture in India. According to national youth policy, persons in the age group of 15-35 are defined as young. At present, 35% of the total population is in the age group of 15-35 years, out of which 75% live in rural areas. Migration of rural youth to cities is around 45% in the country, and it is estimated that only about 5% of youth are engaged in agriculture. Realizing the importance of rural youth in agricultural development especially from the point of view of livelihood security and regular income flow, the Indian Council of Agricultural Research through its Agricultural Extension Division is implementing a project entitled "Attracting and Retaining Youth in Agriculture (ARYA)" since 2015-16. The ARYA project is operational in different states through Krishi Vigyan Kendras and the aim of the project is to attract and empower the rural youth to take up various agricultural and allied sector enterprises for sustainable income and gainful employment in the selected districts. Lower profits in farming on one hand and increased work force in farm families on the other hand are driving youth to migrate to urban areas and elsewhere for jobs in industries. Agro-climatic conditions and advantage of being in National Capital Region (NCR) is ideally suitable for agricultural diversification practices. Despite several constraints the district has great scope for attracting rural youth in agricultural sector by creating agro-based income generating enterprises. KVK Mahendergarh is promoting processing and value addition under ARYA project. Realizing that processing of locally available fruits and vegetables can increase the profitability of the farmers, rural youth group were identified and trained in different aspects of processing and value addition. In addition, packaging, labelling and branding of the produce and maintenance of quality specifications were also imparted as part of entrepreneurship development under ARYA project. For processing and value addition, training programmes for 5 days were organized, where more emphasis was given on practical demonstrations. This group was also exposed to the local post-harvest demonstration units within the district. Under the project 100 rural youth were trained and 22 youths established enterprise for self-employment. The average annual income of each youth is Rs. 30000. KVK provided technical backstopping rural youth groups to establish micro-entrepreneurial units in different enterprises in the cluster villages including support for establishing market linkages.

Keywords: *Agricultural Diversification, Processing and Value Addition, Livelihood Security, Rural Youth*

Impact of frontline demonstrations on foliar application of 'Sampoorna KAU multi mix' in vegetable cowpea in the agroecological zone midland laterite of Kollam district for sustainable yield and income

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Vegetable cowpea (*Vigna unguiculata* var. *sesquipedalis* (L.) Verdcourt) is one of the most important vegetable crops of Kollam district due to its better market prize and consumer preference but its productivity is now at risk due to increasing soil acidity, soil nutrient toxicities and deficiencies in the district. The Krishi Vigyan Kendra Kollam had conducted 30 demonstrations on foliar application of the multi nutrient mix 'Sampoorna KAU multi mix' in the agro ecological zone midland laterite during 2017-2018 and 2018-19. Before the implementation, assessment of soil nutrient status was conducted in the participating farmers' plot. A local check (farmer's practice) was also included as control for comparison. The results on yield and economics of demonstration plots were compared and check plots. Technology gap, extension gap and technology index were calculated. The results revealed that foliar application of Sampoorna KAU multimix enhanced the yield compared to local check from 13.3 t/ha to 16.99 t/ha and 12.56 t/ha to 15.37t/ha with a yield increase of 27.74 % and 22.37% during 2017-18 and 2018-19 respectively. The pooled yield from demonstration plot and control plot were 15.14t/ha and 13.96 t/ha respectively. The technology demonstrated was economically viable as evidenced from the enhanced benefit cost ratio of 1.51 compared to control (1.24). The mean technology gap, extension gap and technology index were 8.82t/ha, 3.25 t/ha and 35.28% respectively. The results indicated that the FLD was effective in the adoption of technology which finally resulted in the enhanced yield and income of farmers.

Keywords: *Frontline demonstrations, Vegetable cowpea, Sampoorna KAU multimix, yield, benefit cost ratio*

Diversification for Nutritional And Livelihood Security In Home Gardens Of Southern Kerala – A Case Study

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Diversification is a heterogeneous process following wide range of possibilities and it ensures economic and nutritional sustainability in farming system. The age-old practice of homestead farming or home-gardening, widely proclaimed as epitomes of resilience, is a viable strategy wherein diversified crops and other enterprises can be grown to compact the disadvantages related to the availability of food and access to markets. As part of the project on 'Socioeconomic analysis and farmer participatory development of homesteads in Kerala' a homestead (0.25 ha with house building in 0.04 ha) in Kollam district, South Kerala was selected based on the survey, for participatory development into a model homestead farm during 2014-2016. An inventory of the resources available with the farmer was initially prepared, evaluated and taking into account the interests of the farmer, interventions were planned and implemented to re-model the existing garden to satisfy the farm needs of the family. The components of the garden included coconut, fruit trees, tamarind, fuel wood trees, agricultural crops (banana, vegetables and tubers), shrubs and ornamental plants. Planting was scattered and the management practices adopted were conventional methods. The interventions in the project for rejuvenation of the homestead included scientific crop management practices and crop rotation, introduction of rain-shelter cultivation and low cost drip irrigation technology, vertical farming and grow bag cultivation of short statured vegetables, ecofriendly pest management (Pseudomonas, fruit fly traps, Beauveria and Verticillium, neem based bio pesticides), organic recycling of farm and kitchen wastes and introduction of a poultry unit (10 birds). Economic analysis of the homestead based on the returns from the farm produce and by products revealed a nearly three-fold increase in the net returns from the pre project period. The benefit cost ratio increased from 3.84 to 4.80, the narrow increase owing to the increased cost of cultivation with the introduction of newer technologies and additional manpower created, the latter which is considered as an advantage with intensification in farmlands. The share of the homestead grown food to the daily family diet increased considerably, more than 50 per cent, glorifying the importance of homestead farming in dietary diversity and nutritional security. In addition, integration contributed to the complementary interactions and synergism in the home garden. The complementary interactions documented include annidation in space, nutrient recycling, multi cropping, soil - moisture conservation and efficient use of by products within the system. The plant residues were recycled as vermicompost, the poultry wastes were crop nutrient sources, the grains formed feed and the tree litter and crop cover ensured soil and moisture conservation. The study has brought to light that farming within the household premises offers a ready source of food, safe and healthy for the family and income. Hence, the homestead model developed as detailed above is a good example for diversification to achieve food security in the state of Kerala.

Keywords: *Diversification, Homegarden, Interaction, Kerala, Resources*

Study of Morphometric Parameters for Best Water Conservation Practices in GKD watershed, Central India by Using Remote Sensing and GIS

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Morphometric analysis was carried out in Garhkundar –Dabar (GKD) watershed located in Tikamgarh District of Madhya Pradesh, Central India. This study involve the watershed geometry and its stream or channel system to evaluate the linear aspects of drainage network, Aerial aspects of drainage basin and relief aspects of channel network and contributing ground slope also. In linear aspects, the maximum frequency in case of first order streams was 19 and that for second, third and fourth order streams was found as 12, 5 and 1 respectively for treated watershed and in case of control watershed, two streams was found consequently with frequency of 6 and 4 for first and second order streams respectively. The total length of stream segments of first, second third and fourth order streams were found as 8.46, 6.61, 2.66 and 0.02 km, respectively in treated watershed and stream segments of first and second order streams were found as 2.72 and 2.91 km, respectively. In treated watershed, length of main channel, basin length and basin perimeter were found as 4.55, 4.16 and 16.63 km, respectively while in the same way 2.84, 3.27 and 7.99 km, respectively were found in control watershed. Drainage area represents the area which is enclosed by boundary line of watershed. By using ArcGIS ver. 10.3, it was found that drainage area of the treated and control watershed was 850 ha (8.50 km^2) and 268 ha (2.68 km^2), respectively. In treated and control watershed, the circulatory ratio (R_c) was estimated to be 0.39 and 0.53 and elongation ratio (R_e) was 0.79 and 0.57, respectively. Total relief was found to be 77 and 31 m for treated and control watershed, respectively. The relief ratio was found as 0.02 and 0.01. Low value of relief ratio is the characteristics of the plain region. The relative relief was found as 0.005 and 0.004 for treated and control watershed, respectively.

Keywords: *Morphometric parameters, Drainage basin, GKD watershed and ArcGIS*

Evaluation of Efficacy of Different Fungicides and Bio-Agents Against Root Rot of Cluster Bean Caused by *Macrophomina phaseolina*

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Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub], popularly known as "Guar" is an important legume crop and mainly grown under rainfed conditions in arid and semi-arid regions of Haryana during Kharif season. This crop suffers from many fungal and bacterial diseases, among various fungal diseases root rot caused by *Macrophomina phaseolina* has become serious problem in recent years in Haryana and in other cluster bean growing parts of India. Management of this disease mainly depends on fungicides till to date. However, fungicidal applications cause hazards to human health and increase environmental pollution. Therefore, alternative eco-friendly approaches for control of root rot of cluster bean are needed. Disease can be managed by seed treatment with bio-control agents at initial stage. Therefore, keeping in view all these facts, the present investigations were carried out at Choudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal (Rewari) during Kharif, 2019. The seed treatments with fungicides/bio-agents alone and also in combination with seed treatments + foliar spray with bio-agents after 30 days of sowing were applied with variable doses. Minimum root rot incidence was recorded in treatment (T6) where, seed treatment with carbendazim @ 2gm/kg seed and foliar spray were applied with *Trichoderma viride* @ 0.4 (15.6%) followed by treatment T7 (19.7%), where seed treatment with carbendazim @ 2gm/kg + foliar spray with *Trichodema harzianum* @ 0.4 were applied on cluster bean crop under field conditions. However, maximum root rot incidence was recorded in control (31.9%).

Keywords: *Cluster bean, disease, fungicides and root rot*

Rainfall Trend Analysis by Mann- Kendall Test for Bhubaneswer, Odisha

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The research of rainfall trend analysis helps to determine the selected river basin's monsoon pattern so as to forecast flood occurrence chances. The purpose of this study is to analyze the trend in rainfall at Bhubaneswar, Odisha, India**.** Thirty years (1969-2007) of monthly rainfall data were analyzed using Mann-Kendall test and Sen's methods for estimating slope. The analysis has been done by the use of XLSTAT 2017 software. Sen's Slope factor (Q) has also been estimated in the study. In Mann- Kendall test, the test statistics (Z_c) for March, April, June, July, September, October, November and December shows a rising trend while Z_c values corresponding to the months, January, February, May and August are showing negative trend during the study period.

Keywords: *Rainfall trend analysis, Mann-Kendall test, Sen's methods*

Evaluation of Anthocyanin Stability During Storage of Color Extracts from Marigold (*Tagetes erecta* L.)

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The flower of Marigold (*Tagetes erecta* L.) has been used for production of food supplements. In this study, various concentrations (75%, and 100%) of ethanol and acetone in water were used as solvent in the extraction of *T. erecta* flower. Present study focuses on the examination and description of anthocyanins, polyphenols and β-carotene from marigold flower. The moisture content showed 81.25% in red petals and 82.85% in the yellow petals of Marigold. Anthocyanins are prone to chemical degradation and colour fading in the presence of ascorbic acid. The color of tagetes was found Anthocyanins (19.03 mg/100g) and TPC (35.07 mg/100g) stored at elevated temperature (45°C/0 days) while, stored at 15 days then found Anthocyanins (19.81 mg/100g) and TPC (35.83 mg/100g). Heavy metal was examined such as Cu (0.53 mg/100 g), Mn (0.42 mg/100 g), Zn (0.71 mg/100 g), Fe (0.59 mg/100 g) and Mg (0.16 mg/100 g) in red petals while, in yellow petals of marigold was found Cu (0.47 mg/100 g), Zn (0.62 mg/100 g), Fe (0.55 mg/100 g) and Mg (0.13 mg/100 g) by ICP-MS. GC-MS was employed for the identification and quantification of the secondary metabolites in marigold. Red pigments marigold have Hexadecanoic acid (18.83%), β-carotene (1.03%), Linoleic acid (4.58%), Linolenin (2.23%), α-D-Glucopyranoside (6.09%), Myo-Inositol (18.31%), Oleic acid (14.89%), Palmitic acid (2.32%) while, marigold yellow pigments have Linoleic acid (3.58%), Linolenin (2.29%), β-carotene (0.23%), α-D-Glucopyranoside (1.18%), Oleic acid (1.56%), Palmitic acid (2.20%) and Vitamin E (0.21%). Results are important for the health benefits of food additive colours consumption due to their composition in bioactive compounds and their nutraceutical properties. These studies are vital for the agricultural and commercial sectors involved in the production of natural colorants, which received the Protected Environmental Symptoms recognition.

Keywords: *Anthocyanin; Heavy metals; ICP-MS; GC-MS detection; Tagetes erecta L.*

Rebuilding Food & Soil Nutritional Security through Pulse Cultivation

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Kerala has been seriously affected by the recent floods occurred. The topographies have been collapsed and resulted in huge loss of vegetation. The floods have caused huge loss in crops, crop produce, soil nutrients and area of cultivation. The losses caused can't be achieved easily but its impact can be reduced by taking suitable *adhoc* measures. These problems can be addressed by cultivating pulses as sole or combined crop as they are drought tolerant, hardy, residual moisture using crops, cultivated in almost all types of soil, even on muddy areas, marginal lands with minimum care and having least cultivation cost. Pulses are those legume species whose kernels either whole or split are utilized for consumption by human. Pulses are very good sources of protein and have qualities like low glycemic index, gluten free and even acts as a functional food. It is the best crop of summer fallows of cereals and areas where rain fed agriculture is practiced. Its short duration lifespan fits it into gap between main crops. It is the best answer to rebuild soil health and crop production which disturbs environment the least. They are efficient protein producers from the minimum resources and fixes atmospheric nitrogen efficiently. They efficiently use light, space, residual moisture and available nutrients for their growth and improve the physical (bulk density, porosity and water holding capacity), chemical (pH, organic carbon, cation exchange capacity and biological (microbial population) properties of soil. They offer less competition with other crops due to their height difference, rooting depth, less moisture and nutrient requirement and effectively control the weed growth due to smothering effect. They can be sole cropped, mono cropped, intercropped, sequentially cropped, mixed cropped and relay cropped. The main pulses to be cultivated are cow pea, green gram, black gram and red gram. Pulses have high carbon sequestration capacity, low carbon footprint, atmospheric nitrogen fixing capacity, low water footprint and soil hydrogen fertilization capacity. It improves soil biodiversity as the root exudates attract soil microbes. Since they are easy to cultivate it creates employment opportunities for women. Pulses give a sustainable income to farmer and thus provides economic security. They can be used as animal feed as well as green manure crop. There lies a concrete, promising, sustainable and cost-effective solution in these tiniest seeds. Despite its importance to man, pulses are regarded as 'orphan crops' as it is not cultivated as sole crop by most of the farmers. Attention is required in production and to create awareness to popularize its significance at present. Pulses are good for people, good for soil and good for earth. They tolerate climate change effectively than other crops. Thus, it is beyond doubt that pulses can help us in rebuilding and regaining our soil health making it more productive for the crops to come.

Key words: *rebuilding; soil nutrition; floods; crop management; food security*

Approaches for Improving Elevated CO_2 induced zinc Reduction in Rice

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A large number of studies worlds over points to the worsening reduction of Zn contents in staple food crops due to increasing CO_2 concentration in the atmosphere. This programme was undertaken to assess the impacts of different methods of Zn application on Zn contents of grain and bran in two rice varieties, Uma (MO16) and Njavara-golden yellow. Plants were maintained under two CO_2 conditions i.e., Low technology polyhouse (420 ppm) and open field condition (390 ppm) with three zinc enrichment treatments (Foliar spray with $ZnSO_4$ 0.5% at panicle initiation and grain filling stage); AMF (3g of AMF inoculum /cavity of protrays); Seed treatment: seed priming with 6.4% $ZnSO_4$ for 36 hr). Zinc concentrations in grain and bran were estimated using Atomic Absorption Spectrophotometer (Analytic Jena company with novAA (300) model). Control plants grown under open field condition without any treatment recorded 18.3 µg g^{-1} and 73.05 µg g^{-1} zinc in grain and bran respectively in Uma and 18.4 µg g^{-1} and 72.25 µg g^{-1} zinc in grain and bran respectively in Njavara. But the corresponding values recorded in the cases of plants grown under polyhouse were 16.2 µg g^{-1} in grain and 63.10 µg g^{-1} in bran in Uma and 17.5 µg g^{-1} in grain and 65.16 µg g^{-1} in bran in Njavara. This indicated a significant reduction in zinc status of grain and bran. Among the tested treatments, 0.5% $ZnSO_4$ foliar spray recorded highest zinc content in grain (25.8 µg g^{-1}) and bran (86.70 µg g^{-1}) in Uma. In Njavara also the same treatment resulted in highest zinc content in grain (25.6 µg g^{-1}) and bran (84.04 µg g^{-1}). In the present study, increasing concentration of CO_2 was found to have a negative influence on zinc contents of grain and bran in the cases of both the rice varieties upon exposure to elevated CO_2 level. This might be due to the accumulation of more amount of carbohydrates or modification of Zn dynamics under such a situation. Supplement of zinc through different treatments improved the zinc status under both the conditions particularly in the polyhouse, an elevated CO_2 condition. Among all the treatments, foliar application of 0.5% $ZnSO_4$ was found to be the most effective one followed by AMF and seed treatments. The information generated will contribute to address the serious health crisis and malnutrition faced globally in this changing climatic scenario. The findings can also help farmers to raise quality produce with the help of low-cost technologies.

Keywords: *Zinc, CO_2, rice*

Diversification of Rice Wheat Cropping System for Sustainability and Livelihood Security

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Diversification of rice-wheat cropping system (RWCS) refers to the addition of new crops / cropping systems to RWCS on a particular farm taking into account the different returns from value-added crops with complementary marketing opportunities. Various problems create in rice-wheat cropping system (RWCS) *i.e.* decline in soil organic matter (SOM), multi-nutrient deficiency, reduced biodiversity, declining factor productivity, buildup of pest, receding water table, environmental pollution, climate change which ultimately are threat in front of sustainable and profitable RWCS. The concept of diversification of RWCS includes a shift of rice-wheat to another crop or cropping system, changing and modifying the spatial and temporal crop/cropping activities and a shift from less sustainable cropping system to more sustainable cropping system. Three major components involved in diversification RWCS; selection of crops, demand and market, profit. The potential options available for diversification of rice in this system include replacement of rice with maize, pulses, oilseeds, cash crops (sugarcane or cotton) and vegetables crops under RWCS has a paramount importance. Hybrid rice-potato-green gram cropping system has an edge in terms of productivity, profitability and nutritional security over rice-wheat cropping system. Crop diversification can help the farmers in introducing the important concerns like crop failure, resource degradation, poor income and purchasing power, lack of productive employment, continuous increase in price of food products etc. Diversification RWCS could be an important tool for increasing productivity, profitability and employment generation. Diversification of RWCS through changing cultivation methods and resource management strategies in rice production system is also possible. Diversification increased farm income, sustainable production and income, food and nutrient security, promotion of export, employment generation, poverty alleviation, and judicious use of land and water resources.

Keyword: *RWCS, Diversification, nutrient security*

Elite Genotype (CA-4) of *Cassia auriculata* Suitable for Crop Diversification, Resource Conservation through Non-Arable Land Cultivation to Ensure Livelihood Benefits in Semi-Arid Regions of Rajasthan

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Many times, research focus given to either trees nor grasses, multipurpose shrubs are a long-neglected life form in the forest or woodland ecosystem, but it provides many economic and environmental benefits to human society. *Cassia auriculata* flower (fresh petals /dried form) was traditionally used by anti-diabetic tea in India, China, Srilanka and other Asian countries. Decoction of leaves, flower and seed is known to mediate antidiabetic effect. In recent years, attractive herbal products developed form *C. auriculata* leaves and flowers were available for sale in Indian as well as foreign markets. Dry flower powder is also having high market value as an important ingredient in many cosmetic and pharmaceutical preparations. In India, *C. auriculata* occurs as a widely adapted and well distributed species under arid and semiarid conditions. The promising genotypes once identified and it can be adopted for successful cultivation to develop sustainable livelihood system. It can also easy fit into afforestation, agro-forestry and soil reclamation programmes as a legume plant with desirable traits in these arid and semi-arid regions. The field study was conducted at research farm area at ICAR-IISWC-Research Centre, Kota Rajasthan during 2016-2019. The field progeny evaluation trial was conducted in a randomized block design with three replications, each containing 30 seedlings. Basic plant growth and yield traits were observed at regular intervals for characterization using standard analytical procedures and methods. The performances of assembled genotypes of *C. auriculata* were shown spectacular morphological variation during field growth and yield production. The progenies of assembled genotypes were showing considerable variation in plant growth and yield performance viz., plant height (avg. mean range varies from 1.16 m to 2.15 m), collar diameter (avg. mean range varies from 18.15 mm to 28.25 mm), no. of stems /plant (avg. mean range varies from 5 to 12) and Avg. flower yield/plant (range varies from 368 g to 740 g) under progeny evaluation trial. Other assessment of temperature stress using various physiological and biochemical attributes were also done among assembled progenies of *Cassia auriculata*. The following genotype viz., CA-4, CA-3 and CA-1 considered as superior or elite genotypes in terms of plant survival, growth, flower yield, and biochemical compounds pertaining to stress tolerance compare to other genotypes. It can also fit into high density plantation, wasteland afforestation, agro-forestry and degraded land rehabilitation programmes as a hardy leguminous medicinal plant. Thus, it can be utilized for afforestation and eco-restoration operations in the ravine drylands. This wonderful native plant has many medicinal and commercial uses which can be utilized after value addition. So, popularization of identified superior genotype (ie.CA-4) among the commercial growers could be highly beneficial to dryland farming community to multiple benefits of meeting the demand of flower production and livelihood security.

Keywords: *Medicinal plant, legume shrub, Tanners Cassia, non-arable lands, Crop diversification, Resource conservation, rehabilitation, Livelihood security*

Estimation of the Magnitude and Nature of Heterosis in Hybrid Rice (*Oryza sativa* L.)

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Rice (*Oryza sativa* L.) is the staple food of Asia, where 90% of rice is produced. Due to decrease in land holdings and water shortage, there is decrease in yield of rice, which is insufficient to meet the food requirement of increased population. So, there is a critical need to develop such rice technologies, which may boost up the yield of rice. For the sake of increase in production of rice, hybrid rice technology is the suitable option to get maximum yield. Hybrid rice technology is a potent option for increasing the production for hybrid rice. Therefore, estimation of heterosis is necessary to identify hybrid vigour, increase in size, growth rate, fertility and yield of hybrid. Present investigation embodies the studies of twelve hybrids developed from crossing three CMS lines and four testers were evaluated for the extent of heterosis for better parents and standard checks for yield and yield contributing traits in rice (*Oryza sativa* L.) during kharif 2018. Three crosses out of twelve hybrids exhibited highly significant heterobeltosis and standard heterosis for grain yield per plant. Heterosis for grain yield per plant was manifested due to the significant and positive heterosis for its components viz., total productive tillers per plant, panicle length (cm), number of filled spikelets per panicle, spikelet fertility (%), 1000 grain weight (g) and harvest index (%). The top two heterotic combinations identified for grain yield plant- exhibited more than 40% heterobeltosis and standard heterosis ranged from 3.64% to 53.45%. Therefore, the estimation of heteosis in the present study can be further used for developing good and high yielding rice hybrids.

Keywords:- *Heterosis, Heterobeltosis, Maintainer, CMS, Tester, Dominance*

Effect of Various Planting Geometry on the Performance of Top Feeds with And Without Intercrop

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Dairy production is an important subsidiary and complimentary farming activity, adopted in Kerala as a part of homestead farming. The major problem faced by the dairy farmer is the scarcity of cheap and quality fodder. In this context, a field experiment was conducted at AICRP on Forage Crops and Utilization, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala during 2017-18 to assess the effect of various planting geometry on the performance of top feeds with and without intercrop. The experiment was laid out in split-split plot design with three replications. The treatment consisted of two cropping system *viz.,* sole crop (C_1-Top feeds) and intercrop (C_2-Bajra Napier Hybrid) as main plots, three different tree fodders *viz.,*F_1- Agase (*Sesbania grandiflora*), F_2- Erythrina (*Erythrina indica*), F_3-Drumstick (*Moringa oleifera*) as subplot treatments and three different planting geometry of top feeds (G_1- 2m×1m, G_2- 2m×0.5m, G_3- Paired system; between pairs-2m, within pairs-1m) as sub-sub plots. The result revealed that growing top feeds with Bajra Napier hybrid as intercrop produced 33 per cent more green and dry fodder yield than that of growing top feed as a sole crop. Among the different top feeds, Agase (F_1) performed far better than the other two (232.6 q ha^{-1} green fodder yield and 48.8 q ha^{-1} dry matter yield) when intercropped with Bajra Napier Hybrid, whereas the yield of component crop (684.1 q ha^{-1} green fodder and 143.67 q ha^{-1} dry matter yield) was found to be significantly superior when intercropped with Erythrina. In case of total yield, Agase performed better than Erythrina and Moringa. Among the planting geometry, growing top feeds under paired system produced significantly superior green fodder yield (166.7 qha^{-1}) and dry matter yield (35.1 qha^{-1}), whereas component crop benefitted more when grown under 2 m x 0.5 m (G_2) geometry and it was found to produce 72.6 per cent more yield than that of paired system (G_3). Interaction effect of cropping system (C), top feeds (F) and planting geometry (G) were also found to be significant both in main crop as well as in intercrop. The study concluded that cultivating Agase with Bajra Napier Hybrid as intercrop under paired system had produced significantly superior yield, whereas component crop yield was found to be superior when grown with Erythrina under 2 m x 0.5 m geometry.

Keywords: *Bajra Napier Hybrid, dry matter yield, green fodder yield, planting geometry*

Commercialization and Diversification of Indian Agriculture

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Indian agriculture has been undergoing spectacular changes in recent period and these changes are manifestations of large-scale commercialization and diversification taking place in the agricultural sector. They broadly include cultivation of new crops and varieties, increase in the share of area under cash crops, large scale spread of livestock activities and fisheries, pursuance of hi-tech agriculture in the areas of aquaculture, bio-technology, horticulture, processing, etc. Commercialization of agriculture is a phenomenon where agriculture is governed by commercial consideration i.e. certain specialized crops began to be grown not for consumption in village but for sale in national and even in international market. Agricultural diversification is one of the essential components of economic growth and it is the stage where traditional agriculture is transformed into a dynamic and commercial sector by shifting the traditional agricultural product mix to high standard products that has a high potential in stimulating production rate. The agricultural diversification is supported by a change in technology or consumer demand, trade or government policy and by transportation, irrigation and other infrastructures development. Crop diversification is an effective strategy for achieving development oriented goals i.e. income growth of farmers, poverty alleviation to rural population mostly, food and nutritional security, employment generation, efficient and judicious use of natural resources like land and water for sustaining agricultural growth and development. Diversification can also accelerate sustainable growth independent of development parameters. For example, adjusting crops to microenvironments of soil and land, spreading the demand for labor, machinery and other inputs, improving health standard, improving cash flows and marketing all can spur sustainable growth in agriculture. Agricultural diversification towards high-value commodities is taking place because of rising per capita income, changing food consumption patterns, increasing urbanization and continuing development of infrastructure, particularly roads. Agricultural diversification has major four objectives i.e. increase in income of small farm holders, generate additional employment, stabilize farm income and conserve natural resources. Diversification and commercialization of agricultural systems is a universal phenomenon that is triggered by economic growth.

Keywords: *Agriculture, Commercialization, Diversification, Development*

Agronomic Interventions in Agri-Horti Systems under Rainfed Conditions

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An attempt was made to assess the effectiveness of agri-horti system under rainfed conditions of Jammu region. On-farm trial was established from *rabi* 2015-16 to *rabi* 2017-18 in existing four-year-old citrus orchard. At the citrus orchard various interventions like- construction of rain water harvesting structure, growing field crops in the inter row spaces of fruit trees, application of recommended fertilizer and manures to the fruit trees as per their age, *etc.* were carried to study the benefits of agri-horti system. Traditionally, intercropping in fruit orchard was practiced under irrigated situation, but with the harvesting of rainwater it was possible to utilize the land unit efficiently by putting it under cultivation of field crops, which helped in increasing both production and productivity. In general, farmers develop orchards for fresh fruit production and do not consider it for intercropping. The study indicated enhanced yield of citrus fruit trees along with intercrops (wheat and mustard taken in *rabi* season and maize and bajra taken in *kharif* season). The mean increase in fruit yield due to interventions, after three years of study was to the tune of 23.0 percent The production of fruits significantly increased due to intercrops and it was maximum in citrus in association with wheat and mustard (4920 q/ha) during *rabi* 2017-18. Mean yield of inter row crops increased by 33.0 percent for wheat, 32 percent for mustard and 45 percent for maize, due to various interventions. Benefit cost ratio increased to 6.2 after three years of study as compared to 4.68 before interventions. System profitability was also worked out and it was seen that Citrus-Maize-Wheat showed maximum profitability of Rs 414/ha/year, followed by Rs.371/ha/year under Citrus-Bajra-Wheat. It was confirmed that citrus based agri-horticultural systems were effective in bringing about improvement in the soil properties as reflected by the significant increase in organic carbon, available nitrogen, phosphorus and potassium.
The study showed that intercrops did not exert adverse effect on the growth and productivity of citrus. The field crops intercropped (raised in the interspaces of the fruit trees) in the orchard provided seasonal revenue to the farm family. Intercropping in citrus was effective in bringing improvement in the soil fertility, leading to a sustainable production system.

Key words: *Agri-horti system, water harvesting, Benefit cost ratio, farm profitability, etc*

Beneficial Insects and Perception of Rural Kashmiri Farmers on Significance of Insect Pollinators

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The pollination and pollinators present significant ecosystem service for human well-being. Identifying and managing diversity of pollinators have significant effect on the conservation and improvement of agricultural yield in terms of quality and quantity on farms. Thus, enhancement of yield needs understanding of farmers' perceptions and knowledge on pollination services and the significance of insect pollinators for agricultural production among other key production and management factors measured. Therefore, the intention of writing this research paper was to investigate and document farmer's perception on the significance of insect pollinators, their current status and farmer's knowledge of the role of insect pollinators in a farmland habitat of the area. In current study, for the collection of data, a well-designed validated questionnaire was used. In the survey, we choose 400 rural farmers from Kashmir valley by stratified random sampling procedure. The data collected was analyzed, tabulated and interpreted statistically. The Statistical software SPSS (version 20) and MS Excel were used for analysis of data. The study revealed that 71.5% of rural farmers reported that their main source of information on insect pollinators was family, 56.5% reported they were aware of climate change, 82.5% reported that they believe there is an impact of agricultural inputs on insect pollinators and 59.5% reported that they have no idea about the decline in insect pollinators year wise. It was concluded from our study that most of the rural farmers did not know about the beneficial insect pollinators and their importance for agricultural productivity and maintenance of ecosystem integrity so there is an urgent need to awareness farmers about the significance of insect pollinators in Kashmir. Finally, it was suggested that government should strengthen the extension department and give continual training to the farmers on pollination and pollinator's significance, its role, impacts of deforestation and chemical use, and why we conserve insects.

Keywords: *Pollinators, Ecosystem services, Perception, Knowledge, Insect conservation, Kashmir, Statistics.*

Integrated Farming Systems –Action tool for livelihood security in tribal areas

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Within the broad concept of sustainable agriculture "Integrated Farming Systems" hold special position as in this system nothing is wasted, the byproduct of one system becomes the input for other. Integrated farming is an integrated approach to farming as compared to existing monoculture approaches. It refers to agricultural systems that integrate livestock and crop production. Moreover, the system help poor small farmers, who have very small land holding for crop production and a few heads of livestock to diversify farm production, increase cash income, improve quality and quantity of food produced and exploitation of unutilized resources. Components of integration in a farming system are trees on bunds, wind breaks, silvi-pasture system, agro-horticulture system, block plantations, economic shrubs, live fences, crops with green leaf manure species (mixed/intercrops), integrated animal based systems (fisheries, dairy, piggery, small ruminants, poultry, apiary).In recent years, food security, livelihood security, water security as well as natural resources conservation and environment protection have emerged as major issues worldwide. Developing countries are struggling to deal with these issues and also have to contend with the dual burden of climate change and globalization.

Keywords: *IFS, livelihood security, food security*

Isolation and Identification of *Mycogone perniciosa*, causing Wet Bubble Disease in *Agaricus bisporus* Cultivation in Jammu

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Button mushroom is an important edible fungus cultivated in Jammu, but it is often attacked by disease causing organisms, including fungi, bacteria and viruses. Some of them cause huge losses by reducing the yield significantly or result in serious crop failures, depending upon the severity and stage of appearance. One of the mycoparasite, *Mycogone perniciosa*, the cause of wet bubble disease, was observed in samples collected from mushroom farms of Jammu districts. This fungal pathogen was constantly associated with the disease and produced typical and characteristic symptoms of wet bubble disease. Isolation of the pathogen was made from diseased fruiting bodies. The pathogenicity proved in accordance with the Koch's postulates both *in vivo* as well as *in vitro*. The pathogen was found to attack button mushroom at all the growth stages but the immature mushroom were found more susceptible than the mature ones, and characteristic symptoms developed on all the inoculated sporophores. The mushrooms were malformed with swollen stipes and with deformed caps. The *in vitro* interaction between *Agaricus bisporus* and *Mycogone perniciosa* mycelia indicated the hyphal collapse of the former at the point of contact between the two fungi. There was no zone of inhibition, found in this interaction.

Keywords: *Yield, symptoms, susceptible, sporophores, interaction, hyphal collapse.*

Homestead: An Approach for Sustainable Living

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Homestead cultivation means, cultivation around the immediate surroundings of a house. Homestead farming is an option open to farmers who seek to increase productivity and income in a sustainable manner. Homestead farming, prevalent in different parts of the world, presents an excellent example of the many systems and practices of agroforestry. The homestead is an operational farm unit in which a number of crops (including tree crops) are grown, along with rearing of livestock, poultry or fish, mainly for the purpose of meeting the farmer's basic needs. The goal of sustainable agriculture is to conserve the natural resource base, protect the environment, and enhance the prosperity of a family or household over a period of time. The United Nations General Assembly has declared the year 2014 as International Year of Family Farming, recognising the importance of this system of farming in conserving biodiversity, household nutritional security, and in maximising production. A study was taken up in Wayanad district of Kerala to assess the economic contribution and structural and functional diversity of homesteads among the small and marginal households. It was observed that there was rich diversity in structure and functions of the homestead. On an average there are 43 species of different plants in the homesteads of average area 0.43 hectare. Majority of the households depends on the homesteads for their daily consumption needs of different food groups. These homesteads also play a major role in providing the employment throughout the year to the family members especially women and children. The consumption pattern of the households was analysed. It was found that out of the total consumption of the different food groups, 55 per cent of vegetables, 66 per cent of fruits, 68 per cent of tubers, 87 per cent of oil consumption are met by the homesteads alone. The farmers were able to generate an additional income of ` 22,213.75 from the crop cultivation taken up in homestead and ` 63,028 from the animal products. John and Nair (1999) also revealed that 17.5 and 30.25% of the homesteads raised cattle and poultry, respectively, as a complementary enterprise. Homestead farming satisfies the requirements of sustainability by being productive, ecologically sound, stable, economically viable, and socially acceptable. However, land-use changes, availability of agricultural labour, and falling commodity prices are major constraints in homestead farming in Kerala. Studies conducted in homesteads revealed that the addition of nutrients from various sources (litter fall, stem flow, organic manure, and fertilizer) compensates for the loss of nutrients from the system through harvested biomass. Nutrient cycling processes that take place to varying degrees in all land-use systems become particularly relevant in homesteads because of the effect of trees on such processes. Homestead farming ensures sustainable use of natural resources for the benefit of present and future generations.

Keywords: *Homestead Farming, Kerala, Nutrient, Sustainability*

Screening of Chilli Varieties Against Insect Pests Infestation

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A two-year field trial was conducted at Vegetable Research Centre of Pantnagar during the year 2018-19 and 2019-2020. Fifteen chilli varieties were screened against insect pest infestation. The morphological and biochemical characters of these varieties were further correlated with insect pest infestation. Sonia-778 recorded highest amount of protein (13.81 mg/g leaf tissue), total sugar (45.79 mg/g leaf tissue) and phenol content while lowest amount of proline (4 micro moles/ g leaf) content was reported in it in the minimum amount. These biochemical characters were correlated with insect pest infestation; protein and total sugar content which were found to be positively correlated with insect pest infestation while proline content had negative and significant effect on insect pest population. Pant C-1 recorded minimum amount of protein (7.71 mg/g leaf tissue), total sugar (25.40 mg/g leaf tissue) and phenol content while highest amount of proline (6.00 micro moles/ g leaf) content. The varieties were also screened for certain morphological characters where plant height of all the varieties had positive and highly significant association with insect pest population. While trichome density had negative and highly significant impact on insect pest population on chilli crop.

Keywords: *Screening, protein content, Pant C-1, varieties*

Carbon sequestration potential in relation to soil microbial population under different Cropping systems in Coastal Saline Soils

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Different cropping systems significantly change the soil physical and chemical properties, and hence plant growth and crop yields will be affected. Soil samples were collected from different farming systems such as cereal, oilseed, horticulture, vegetables, pulses, cashcrop, fodder, spices and wasteland from salt affected coastal soils of Gujarat, India. Soil carbon stocks and microbial population under different cropping systems were studied in coastal salt affected soils. Soil physical, chemical, biochemical characteristics, exchangeable cations, available nutrient status and microbial biomass varied considerably with different cropping system. The microbial communities more closely related to different properties of soil. The microbial biomass consists mostly of bacteria and fungi, which helps in decomposing crop residues and soil organic matter to enable release of nutrients into the soil that is available for plant uptake. Soil properties such as pH, EC, texture and organic carbon content influences the size of the microbial biomass.

Soil microbial biomass carbon (MBC) was observed to be higher in soil under spice crops about 600 mg/kg in compare to cashcrop like cotton where it was observed lower. Microbial biomass nitrogen (MBN) was maximum (87.5 mg/kg) in soils under cereals and minimum (19.5 m/kg) in wasteland system. Carbon stocks such as organic and inorganic C stock were observed to be maximum in soils from vegetable and cashcrop system, respectively having content of 21.68 Mg/ha and 9.91 Mg/ha and minimum in oilseed (6.21 mg/ha) and wasteland (2.82 Mg/ha), respectively. Soil enzyme activities such as alkaline phosphatase activity was observed maximum of 54.25 µg PNP/g/h in sub-surface layer in cereal in compared to wasteland having minimum of 15.25 µg PNP/g/h in sub-surface layer whereas acid phosphatase activity was higher (24.75 µg PNP/g/h) in surface layer of soil in Horticulture system and lower (5.25 µg PNP/g/h) in sub-surface layer of soil in pulse system; dehydrogenase activity was maximum of 85.35 µg TPF/g/h in surface layer in cashcrop and minimum of 1.465 µg TPF/g/h in sub-surface layer in waste land.

Keywords: Soil carbon stocks, microbial population, biomass C, land uses

Integrating Sustainability and Environmental Impact Assessment in Agriculture

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Environmental impact assessment (EIA) has been identified as an important instrument for facilitating sustainability. However, to do so requires the integration of sustainability into EIA theory and practice. The sustainability concept is a valid and important environmental management perspective. However, many issues and obstacles need to be addressed further if the concept is to be translated into practical strategies. Sustainability can potentially infuse EIA with a clearer sense of direction, an ethical foundation, a mechanism for establishing priorities and assessing choices, and a means of linking EIA to other environmental management instruments. Conceptually, EIA and sustain-ability can be integrated, but frameworks should be refined, adapted to context, and linked to related initiatives. Sustain-ability should be explicitly incorporated into EIA legislation, guidelines, and institutional arrangements. An experimental approach to testing, assessing, and sharing experiences is suggested. A framework is first presented that defines and characterizes the sustainability concept. A further framework is then described for integrating sustainability into EIA at the conceptual level. The integration of sustainability and EIA at the regulatory level is next addressed through an overview of sustainability initiatives in EIA requirements in India. The Indian examples include many promising initiatives but these and other experiences will need to be monitored, shared, and integrated into comprehensive environmental management strategies. Finally, means of incorporating sustainability into each activity in the EIA planning process are identified.

Keywords: *Environmental impact assessment, environmental management, sustainability*

Crop Diversification Options to Manage Rice-Fallow and to Catalyse Farm Productivity and Profitability in Odisha

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Odisha is an agrarian state with rice as a staple crop. According to the Odisha economic survey of 2018, the crop diversification Index has decreased drastically in the last few decades. The cropping system that is mainly practiced in Odisha is rice-fallow. Farmers tend to leave the land fallow after harvesting of rice crop. Rice-fallow area in Odisha is about 2 Mha. Rice-rice cropping patterns have been conventional methods for decades. Diversification strategies help in contributing to food security and developing resilience to climate change. In this study, we diversify rice-fallow through groundnut to evaluate productivity as well as the farmer's income. Further, due to less availability of water in the summer season and more requirements, the flow in the river is insufficient for raising summer rice. In search of a suitable alternative, groundnut was grown utilizing the residual moisture succeeding Kharif paddy. On comparison with summer rice, it was found that the drill seeded groundnut variety Devi gave a yield of 21.5 quintals per hectare in 120 days with a paddy equivalent yield of 7 t/ha. It was also found that the system equivalent yield was approx. 13 t/ha as compared to 12 t/ha in the rice-rice system. When the cost analysis was done, it was found that with an investment of around Rs. 54000 per hectare the groundnut crop gave a gross return of around Rs. 100000. It could save 37.7% fuel, 40% energy and 80% irrigation water. Hence, it can be concluded that the groundnut has the potential of diversification of the rice-rice and rice-fallow systems in Odisha. With fewer resources in terms of investment, labour and water for irrigation, groundnut proved to be a viable option in place of summer rice. Moreover, climate-resilient varieties of groundnut are required to withstand harsh climatic conditions to averse the risk of crop failure. Community approach and better coordination between state government and different farmer's organizations can help to raise awareness among farmers to diversify their cropping systems and make better use of resources to attain sustainable livelihood.

Keywords: *Crop diversification, rice-rice system, rice-fallow system, climate change, yield attributes and resource conservation*

Auto Tilling Effects of Potato Cultivation: Saving of Energy, Time and Cost of Production For Next Crop

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Area under potato cultivation in India is more than 2.085 M ha with total production 48.096 M tonne and corresponding average productivity of 23.07 tonne/ha. A good potato crop can give much higher yield in the range of 40-70 tonne/ha. Potato is generally planted over ridge-furrow system however it is still being planted over flat beds. Potato requires well pulverized fields for good production. The true average density of potato is about 1.067 kg/m^3. Potato is a tuber crop hence when grows within the soil system it increases the overall soil volume resulting to decrease in bulk density. Potato tubers are generally present in top 15 cm soil layer resulting to cracks in soil consequently reduction in bulk density and increase in porosity of soil, infiltration rate and water storage capacity. This positive change in soil happens in presence of standing crop is termed as autotillage. The volume of soil displaced by the well developed potato tubers at full maturity range from 37.488 to 65.604 m^3. Potato planted on flat bed would increase overall soil volume from 2.499% to 4.377% consideration presence of potato tuber in top 15 cm soil. Potato planted over ridge with a base width of 30 cm, top width 15 cm and height 30 cm would increase overall soil volume by 3.357% to 5.874%. Potato tuber growth within soil results autotilling effect by decreasing soil bulk density and increasing porosity, infiltration rate and soil storage capacity. Auto tilling effects of potato cultivation would drastically reduce the tillage requirement of next crop by 50% to 75% resulting to significant saving in energy, time and cost of crop production.

Keywords: *Autotillage, bulk density, infiltration rate, porosity*

Agricultural Diversification Fortifying Livelihood

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India is standing up to the most erratic trial of lessening territory man extent, creating issue of people and joblessness, changing food affinities for clients and speedy changing business area due to globalization. Other than these issues during past decade ensuring about occupations have been logically seen as a critical segment of viable new development. Regardless, in India, land-based occupations of little and negligible farmers are logically getting preposterous, since their domain isn't, now prepared to meet the necessities of sustenance for the family and grub for their dairy animal. The greater part of little and minor farmers grow predominantly low worth, asset crops. As extended farms are more grounded to promote move, give protection from ecological change and showed the most noteworthy hotspots for poverty decline with assembles pay of the farmers. Thusly agricultural diversification gave one way to deal with vanquish these repealing issues in a more genuine condition as a technique to ensure occupation security through employment generation, poverty alleviation and conservation of natural resources, and safeguarding of conventional resources. Therefore, in a subsistence agricultural system, improvement is considered as a method to restrain farm risk, which develops in light of fluctuations in yield costs, atmosphere weaknesses and bug frequencies, etc. Even more definitively in the time of business and market-drove cultivating, regardless, diversification is a growth strategy which replaces the asset endeavors with the viable and profitable ones.

Keywords: *globalization, diversification, farmer, extended farms.*

Integrated Farming Systems for Sustainability and Enhancement of Rural Livelihoods – A review

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In the current agrarian era, most of the rural farm households are small and marginal and live under extreme poverty with low livelihood security. They poorly adopt to the changing farming scenario and are very much susceptible to the natural vagaries like drought & flood which result in their large-scale migration to urban areas for better livelihood opportunities. Integrated farming systems can help these farmers to attain a sustainable and environment friendly improvement in farm income, family nutrition and ecosystem services through judiciously taking up two or more components or enterprises having minimum competition and maximum complementarity in their farms. For the purpose of national food security, price or income stability and protection of bio-diversity, there is need for maintaining a tender balance between those farming activities which are potentially more profitable and those which are relatively less profitable, but ecofriendly. Integrated farming systems involve integrating agriculture with allied enterprises like dairy, poultry, mushroom cultivation, pisciculture, sericulture, vermicopost etc. This can generate on-farm employment all-round the year. Various number of products are obtained from the system which could supply various nutrients needed by the farm family. The waste obtained from one enterprise can be used as input for another enterprise. The recycled biomass, besides being a source of inorganic nutrients for plants, is a substrate for micro-organisms and a factor in soil aggregation, root development and soil and water conservation. The high biodiversity existing within the system could reduce the impact of climate change, damage due to pest and disease and thereby help in building more sustainable and resilient farm ecosystems.

***Keywords*:** *Integrated farming systems, sustainability, livelihood security*

Protected Cultivation: Boon for Farmers of Kashmir to Improve Livelihood

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Kashmir being cold and high-altitude region of India has a very harsh climate and a short agriculture season. Due to extreme long winter, the agriculture season is short, which extends from May-September in general, and in case of particular location, it depends upon altitude. During winter season most of the regions remain cut off from the rest of the country from December to February due to heavy snowfall. Due to this reason, local people in these areas experience shortage of fruits and vegetables in winters. Protective cultivation such as poyhouse, shade net, anti-hail net which protect fruit and vegetables against hail and mulch which protect plant roots from extreme hot and cold temperatures, ensure the quality production of any plant at any place throughout the year with minimum attack of insect-pests and diseases. It saves upto 75 % water and 30% fertilizers as compare to crops growing in open fields as drip irrigation system are used for fertigation and irrigation. Fruits and vegetables such as kiwi, mulberry, tomato, onion, green leafy vegetables, seedlings and grafting are being grown throughout the year under polyhouse. Beside cultivation polyhouse are also used as animal shelter in the region such as sheep shelter. Cultivation under polyhouse help to enhance the cost benefit ratio for the cultivated crops. The cultivation under polyhouse could help to improve capacities of local farmer which could help to improve the livelihood and nutrition security of the Kashmir region over traditional practices.

***Keywords*:** *Protected cultivation, livelihood, polyhouse*

Post-Harvest Technology and Value Addition in Phalsa (*Grewia subinaequalis*)

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Phalsa (*Grewia subinaequalis*), also known as star apple, is an underutilized minor fruit of India. The fruit contains several bioactive compounds like anthocyanins, phenolics, flavonoids, tannins, and antioxidant vitamins, which exhibit very high antioxidant activity. Being a rich source of nutraceutical compounds, ripe fruits are beneficial for heart and liver disorders, cancer, anorexia, hiccough, asthma, stomatitis, diarrhea, throat infection, tuberculosis, etc. The fruits of phalsa are highly perishable, having shelf-life of only 1-2 days at ambient conditions. Fruits harvested at the turning stage can be stored about a week at 70C in cold storage. The juice is incredibly refreshing and is considered to have a cooling effect, especially in the hot summer. Heating the crushed phalsa fruit to 50oC gives the highest recovery of the juice with an appropriate quantity of anthocyanin and other soluble and insoluble materials. Studies have shown that the addition of cane sugar to the juice has a protective effect on color stability. Syrup and squash can also be prepared with phalsa fruit juice after mixing with sugar and preserved with sodium benzoate. Postharvest losses of this fruit can be minimized by the development of value-added products viz. ready-to-serve (RTS), squash, sherbet, etc.

Keywords: *Phalsa, Nutraceutical compounds, Technological intervention, Squash, Cancer, and Sodium benzoate*

GUM: By-product of rice bran oil refining

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India is the second largest producer of rice in the world next to China. Rice is good source of carbohydrates, which serves as a form of energy. Rice bran oil is popular as cooking oil in several South and East Asian countries, including Bangladesh, India, china and Japan. Rice bran oil is the oil extract from the hard outer layer of rice called chaff (rice husk). Rice bran is a major milled rice by-product and used in oil mill industry for producing Rice bran edible oil. After extraction of oil from rice bran, gum is produced. Gum is used in factory for making lecithin of the most important ingredients. The by-product such as lecithin which is used as an ingredient of making wide variety of food, Anti-dusting Agents, Nutritional supplements, cosmetic soap that world save huge amount of foreign currency and create employment significantly. The Shree Seeta Refinery and Kamal Solvent Pvt. Ltd. Durg Chhattisgarh is producing a good amount of edible oil and also a good amount of other valuable by-products such as FFA, gum, wax, splint earth. These products have very high demand in market especially lecithin in factories. So that the by-product can be make a good valuable product. Through technological interventions these two industries are converting by-product and waste of rice bran refinery oil into some good quality extra apart from the product of rice bran oil these industries are also providing marketable good through by-product and creating employment and opportunity for the young in this industry. Through employment it is also sustaining live hood security of rural youth in Ranjandgaon district of Chhattisgarh.

Keywords: *Rice bran oil, by- product gum, lecithin, wax, Anti-dusting agent, cosmetic soap*

Designing and Evaluation of Low-Cost GPS based Integrated Solar Hammering Drum

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The year 2020 insights several challenges and hidden opportunities that have been overlooked by the policymakers. The Covid-19 pandemic threatens the existing agriculture system and made vulnerable millions of people globally. The situation worsens due to continuous lockdown in highly populated developing countries like India that lead to unemployment, migration and starvation of daily wages community. The severity of food shortage intensifies with locust's storm attacks in several regions of Africa and Asia. The FAO reports worst-case forecast predicted severe damage in areas where major rabi crops (winter-sown crops like chickpea, pulses, oilseed) grow. Despite several creative methods used by farmers like beating metal plates, bursting crackers, playing drums, radio and loudspeakers and even roaring their tractors, they were unable to reduce the damage. This is alarming and high time to think and reorient our food production system to a better climate-resilient farming system with the integration of technology to averse the risk associated with such catastrophic events. This study proposes an innovative solution to design and evaluate high-frequency GPS based integrated solar hammering drums to avoid grazing that offers cropping in rabi season. Furthermore, the installation of a high-frequency GPS based integrated solar hammering drum reduces the damage by locust's storm attack. The GPS based integrated solar hammering drum will offer a win-win situation through manifold benefit in terms of economic, social and environmental perspective. The management of rice fallows intensifies and diversify the cropping system. Their productive utilization can overcome many social and economic constraints such as unemployment, labour migration and low income. Development and popularization of crops suiting to rice fallows of different agro-ecological regions coupled with our proposed GPS based technology will boost production and thus improve the income and livelihood of the small and marginal farmers, especially women.

Keywords: *Cattle grazing, bat eating fruits, antelope, labour shortage and drudgery*

Solar Based Automatic Water Pumping System for Agriculture Purpose in Upper Hilly Region of India

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The biggest problem in today's scenario for India is the shortage of electricity or to fulfill the electricity requirements in the upper hilly region. The problem rises if we talk about the villages in upmost part of states where electricity still is just a dream. The life is immense tough over there, even the basic regular works like water arrangement for daily needs, mobile phone charging, transportation etc, are seems to be a huge task for daily life, people has to walk many kilometers to fulfill their basic requirements. As the regions are dully filled with the waterfalls and small rivers, the water can be pump up from these sources and the huge water tank can be constructed to the required regions to irrigate the lands for farming as per required for the crops. Now, the problem of electricity can be sought out by installing the solar panels to the water sources to pump water to the tank. The solar water pump system is fully automatic and does not require any manual operations. Solar panels can directly energize the drive to start the submersible pumps according to the water level in the tank. A water level indicator with relay cut-off will be install in the tank and as the water level goes down the pump starts itself and turn off while the water reach the level. This system can be made in the steps or say tank wise through which water can be delivers to the upmost part of the regions and the land can be irrigated so that migration from hilly regions can be control and people can do farming to survive and earn well. System is build up with the main components like solar panel, VFD drive, water level indicator, relay cut off system, surface/submersible pumps and the huge water tank according to the need of capacity required. Water is suctioned by the nearby source, pumped by the submersible, energizes by the solar panels and controlled by the variable frequency drives, further deliver to the storage tank for use of irrigating the cultivating land. As the system is build up with the water level indicator and relay cut off system, there is no need of manual operation and thus the system will works itself which means more convenience and reliability.

Keywords : *Automatic ,Solar Energy ,Water , Pumping System, Agriculture, India etc.*

Farmers' Behaviour towards Adopting Conservation Agricultural Practices in India

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Achieving food security for an escalating population and lessening poverty while sustaining agricultural systems under the current scenario of exhausting natural resources, adverse impacts of climatic changes, spiraling cost of inputs and unstable food prices are the major challenges in front of Indian Agriculture. The tillage intensive conventional cereal-based cropping systems often led to advent of second-generation problems of green revolution *viz.*, decline in soil organic matter, soil degradation, emergence of multi-nutrient deficiency, soil compaction, crop residue burning *etc.* leading towards non-sustainability in long-term. Conservation agriculture can be seen as a new way forward for conserving resources and enhancing productivity by residue retention, crop diversification to achieve the goals of sustainable agriculture, which demands a strong knowledge base and a combination of institutional and technological innovations. In India, applying CA practices in different cropping systems has resulted in enhancing the yield, reducing the cost of production and lessening the mining effect of the soil nutrients when grown under rice-wheat cropping system. Besides ensuring sustainability, CA also helps in generating employment among farm youths, lowers the input cost and increases the overall farm productivity and thereby ensuring livelihood security. But the penetration of CA technologies is gaining momentum at a slower rate. In spite of these multi-dimensional benefits of CA, its spread and adoption in India is still very low. Most of the studies on CA are mainly concentrated on its adoption among the farmers in India and their results reveal a low adoption rate. There is still a lack of clear evidence to understand why/how farmers voluntarily adopt improved technologies, sustainable practices and here complex behaviour plays an important role to influence the ultimate decision process of farmers. Hence, there is an urgent need to shift the focus towards behavioural aspects. Various social science constructs like knowledge, perception, behaviour of farmers with respect to CA practices, institutional role need to be measured through standardized tests and scales which are largely the ignored areas in scientific discourse.

Keywords: *Conservation agriculture, Farmers' behaviour, Adoption, Constraints, Social science*

Weed management in *Bt* cotton (*Gossypium hirsutum*) influences the yield through sequential application of herbicides

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A field experiment was conducted during Kharif of 2018-19 at Krishi Vigyan Kendra farm Raichur, Karnataka under TBP irrigation command area to study the effect of sequential application of herbicides on weed management and its influence on crop yield. Continuous usage of same or similar herbicides over several years do certainly lead to the development of herbicide resistant weed flora and also cause residual effect in soil and it may affect the succeeding crop in future. The experiment comprising of 11 treatments having three PRE (metolachlor, diuron, pendimethalin) applied twice at 45 and 60 DAS and one POST (pyrithiobac sodium) applied at 60 DAS in sequence with PRE herbicides and also consist of weed free check (two hand weeding @ 15 and 30 DAS fb IC at 45, 60 and 75 DAS) and weedy check.. Among all the herbicidal treatments significantly lower weed count (3.62 m^{-2}), lower weed index (7.28 %), and also significantly higher weed control efficiency (90.22 %), higher number of bolls per plant (43.87 $plant^{-1}$), higher boll weight (5.55 g) and higher seed cotton yield (2578 kg ha^{-1}) were recorded in Pre followed by post emergent herbicides Viz., metolachlor 50 % EC @ 1000 g a. i. ha^{-1} as PRE fb Pyrithiobac sodium 10 EC @ 125 g a. i. ha^{-1} as POE @ 2-5 leaf stages of weeds fb IC @ 60 DAS, diuron 80 % WP @ 1500 g a.i. ha^{-1} as PRE fb Pyrithiobac sodium 10 EC @ 125 g a.i. ha^{-1} as POE @ 2-5 leaf stages of weeds fb IC @ 60 DAS and pendimethalin 30 EC @ 1250 g a. i. ha^{-1} as PRE fb Pyrithiobac sodium 10 EC @ 125 g a. i. ha^{-1} as POE @ 2-5 leaf stages of weeds fb IC @ 60 DAS and it was on par with the weed free treatment.

Key words: *boll weight, weed control efficiency, weed count, weed index and seed cotton,Yield*

Farmers Perception about Organic Farming in Rampur district of Uttar Pradesh

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Organic farming is a holistic production management system which favours maximum use of organic materials and discourages use of synthetically produced Agro-inputs, for maintaining soil productivity, fertility and pest management under conditions of sustainable natural resources and healthy environment. Awareness about organic farming is increasing in Rampur district and even small number of farmers have converted and started organic farming. But majority of the farmers in the district are still engaged in commercial agriculture and adoption rate of organic farming practice is not significant. Cultural and demographic attributes of the farmers play an important role in adoption/ rejection of new technologies/alternative method. There is need for proper socio-cultural environment for promotion of organic farming in the state. The present study was conduct in Rampur district. The district Rampur having six block, out of these two block Milak and Swar were selected, purposely depending upon the higher number of organic farmers. A random sample of 40 organic farming practicing farmers from each of two blocks was taken. Total number of 80 farmers constituted the sample for the purpose of study. The finding indicate that nearly half of the farmers had highly knowledge, very few of them had low knowledge and remaining had medium knowledge about organic farming practices. The study revealed that the knowledge percentage about the use of biofertilizer was also quite high (72.91%). Three-fourth of the respondents (75.00%) were found to have high level of knowledge followed by medium level (15.00%). However, only (10.00%) respondents belonged to low level of knowledge regarding use of biofertilizers in organic farming. So far as the organic weed management was concerned, the knowledge was 65.62%. Moreover, 55% of the respondents had high level of knowledge, those who had medium level of knowledge were 30.00 per cent. There were 15% respondents who had low level of knowledge about weed management with regard to organic farming. While the study in hand showed that the knowledge percentage of vermicompost was 60.41 per cent and accorded last rank order out of six organic farming practices. The knowledge level of respondents regarding pest management was 54.37% which included cultural methods, mechanical method, biological control, diversification such as crop rotation, intercropping, trap cropping and also include safe storage of produce was minimum. This low level of knowledge was due to complexity of some of the above technology and lack of government support to the organic farming till date. While looking on the distribution of respondents with regard to knowledge level about pest management practices in organic farming, almost equal number of respondents belonged to medium (41.25%) and high (40.00%) knowledge level. Whereas, 18.75 per cent had low level of knowledge about it. Education, mass media, exposure visit and innovativeness were positively and significantly related to the knowledge level. Organic farming practices are new to the farmers and hence, the knowledge levels are low in most of the practices. The farmers need to be made well aware about the use of such practices so that the basic concept of organic farming and its application part could be made well known to the farmers.

Keywords: *Organic farming, knowledge, Mass media, exposer visit*

Quantification of Agro-meteorological Observations of Barley (*Hordeum vulgare*) Cultivars Under Varying Growing Environments

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Field experiment was conducted during rabi season of 2016-17 and 2017-18 at research farm, Department of Agricultural Meteorology, CCS HAU, Hisar located at 29° 10´ N latitude, 75° 46´ E longitude and 215.2 m altitude. The experiment was put in a split plot design and comprised of four sowing dates (main plot treatments) viz. D_1- 3rd November; D_2- 18th November; D_3- 3rd December and D_4- 19th December; four sub plot treatments comprising four different varieties viz. V_1 (BH 393), V_2 (BH 902), V_3 (BH 946) and V_4 (BH 885) during crop season 2016-17 and 2017-18, respectively with three replications. The experimental results revealed that significantly higher intercepted radiations were gained in D2, D4 and D1 sown crop at 45 DAS, LAI_{max} and maturity, respectively during crop season 2016-17 (Table 4.15). However, during the crop season 2017-18, the significantly higher intercepted radiations were gained in D4 sown crop at 45 DAS and LAI_{max} phases whereas, D2 sown crop at maturity. However, V4 (BH 885) variety received higher intercepted radiation at 45 DAS, LAI_{max} and crop maturity during crop season 2017-18. The chlorophyll content was recorded significantly higher in D_1 as compare to other dates of sowing. The highest values of chlorophyll content was observed in V_4 (BH 885) variety at 45 DAS, LAI_{max} phase and at crop maturity (PM) during both the crop seasons. A comparison between two years study, the higher chlorophyll content was recorded during crop season 2016-17 as compare to crop season 2017-18. The highest PAR observations were recorded in D_4 sown crop at 45 DAS, maximum LAI and crop maturity phase, respectively during both crop seasons except D_2date of sowing, which stands first at 45 DAS during crop season 2016-17. Among varieties, the non-significant results were obtained of PAR observations in barley with same values were observed at different growth intervals among all the treatments during both crop seasons.

Key words: *Growth intervals, Phenophases variation, Growing environment, Yield.*

Effect of Different Cropping Systems and Tillage Practices on Yield of Indian Mustard Under Rainfed Conditions of Jammu

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An experiment was conducted at Research farm, Main Campus, Chatha of SKUAST-Jammu during the *kharif* and *rabi* season of 2019-20. The experiment consisted of 12 treatments and was laid out in Split Plot Design with 3 replications study the effect of different planting methods under mustard-based cropping systems viz. Raised bed planting system, zero tillage and conventional tillage on succeeding crops viz. Maize, Pearl millet, Green gram and Sesame in Zone II i.e. Jammu region. The variety NRCHB 101 was sown in this experiment which was arranged in split plots with three replications. The experiment was initiated during the *rabi* season 2017-18 at Advanced Research Centre for Rainfed Agriculture, Dhiansar with 3 tillage methods viz. Raised bed planting system, Zero tillage and conventional tillage as main plots and succeeding crops namely Maize, Pearl millet, Green gram and Sesame which were sown in sub plots during the preceding *kharif* season. All the standard package and practices besides the procedures were followed. During the rabi season 2019-20, among the different tillage methods (main plots), significantly higher seed yield was recorded in raised bed planting (1658 kg/ha) plots which was found to be at par with plots with conventional tillage (1501 kg/ha). Lowest seed yield was recorded in plots where Zero tillage (1355 kg/ha) was followed. Among the different mustard-based cropping systems in sub plots maximum seed yield was recorded in sub plots sown with green gram (1637 kg/ha) which however was statistically at par with plots sown with Sesame (1524 kg/ha). The plots sown with Pearl millet (1433 kg/ha) and Maize (1424 kg/ha) though at par with each other were found to give significantly lower yield than Mustard-green gram and mustard-Sesame cropping systems in comparison.

Keywords: *mustard, pearl millet, cropping systems, rainfed*

Fodder Cultivation: An Option to Conserve Rice Summer Fallows

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The conservation of summer rice fallows is a prime concern as it is a static source of rice production. However, the main threat to the summer fallow is weed population, which take up the soil moisture along with nutrients. This in turn poses deficiency of moisture and nutrients to the subsequent rice crop. Thus, the better option to conserve the summer fallow is to cultivate the land with suitable crops. At this context, in the summer rice fallow of double cropped low land rice filed, four different fodder crops were raised under varying nitrogen regimes with the objective of evaluating its effect on weeds, during 2017-18. The experiment was laid out in Randomized Block Design. The fodder crops were fodder cowpea (CO- 9), rice bean (Bidhan-2), fodder maize (African tall), fodder sorghum (CO (FS) 31). The varying nitrogen regimes were 100, 75 and 50 per cent recommended dose of nitrogen (RDN). The weed composition in the experimental field included grasses, sedges and broad-leaved weeds. Both at 20 and 40 DAS, the weed population was more in fallow treatment. The weed dry matter production was significantly more in the fallow plot. At 40 DAS, weed dry matter production was relatively less in fodder cowpea. Weed smothering efficiency (WSE) was relatively greater in all the fodder crops except fodder cowpea at 20 DAS. However, at 40 DAS the WSE in rice bean, fodder maize and fodder sorghum declined, while in fodder cowpea it increased. Nitrogen removal at 20 and 40 DAS was significantly more in fallow plot. At 40 DAS, both N and P removal by weeds was significantly less in fodder cowpea. At 40 DAS, K removal was significantly less in fodder cowpea especially at 100 and 75 per cent RDN.

Keywords: *Weeds, fodder crops, nitrogen, summer rice fallows, conservation of fallow land*

Assessment of Training needs in Knowledge of Banana Growers in Kerala

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Banana (Musa species) the "queen of tropical fruit" is considered to be one of the oldest fruits known to mankind. Banana is considered as the most important energy providers'food and is a good source of mineral, salts and vitamins. In India, banana is largely grown in Tamil Nadu, Kerala, Maharashtra, Andhra Pradesh and Bihar. It is the second most important fruit crop in India next to mango. Production alone constitutes 32 per cent of the fruit production in India. The contribution of banana to GDP (Gross Domestic Product) of agriculture in India is 2.80 per cent. The productivity of banana in Kerala is 13.8 tha1 (Source: Directorate of Economics & Statistics, Kerala) in 2014 Whereas, it was 46.1 tha1 in Tamil Nadu (Source: National Horticultural Board). This productivity difference is due to lack of information and skills among farmers about the cultivation strategies of banana. The basic problem is not of natural resources but it is of the human resources. Hence, it is required to strengthen human capital through an effective system of extension training and education. Keeping the above in view, a research study on training needs of banana growers in Palakkad district of Kerala, has been articulated with the following objective: To identify the training needs in knowledge related to banana cultivation The study was conducted in Palakkad district of Kerala purposively as Palakkad has highest number of banana growers by adopting Ex-post- facto research design. The study has been taken up in three blocks covering twelve villages of Palakkad district. A sample of 120 banana growers were selected based on proportionate random sampling method. High training need items in knowledge were high density planting, organic manures, application of micronutrient, diagnosis of important insect pests and diagnosis of important diseases etc. And the items under moderate training needs were use of rotovator to break clods, selection of variety, type of suckers, selection of suckers, method of planting, dosage of fertilizers (NPK 100 - 200 - 400 g / plant /year), method of application of fertilizer, time of application of fertilizers, application of liquid fertilizers through drip irrigation, *in situ* green manuring, application of biofertilizers, pre harvest bunch spray, application of growth regulators, no: of irrigations to be given to banana crop, irrigation interval, method of irrigation (drip, furrow, basin) methods of drip irrigation, propping, bunch cover, time and method of harvesting, grading, storage and marketing etc. Required temperature for banana cultivation, required relative humidity for banana cultivation, required mean sea level for banana cultivation, sucker treatment, mulching, desuckering, packing and transportation were the items under low training needs of banana growers.

Keywords: *Banana growers, Knowledge, Training needs.*

Technological Advancements in water and heat Stress tolerance Related Traits Measurement in Wheat

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The climate change and resulted increase in the environmental temperature is a potential threat for the agriculture and its associated sectors. Bread wheat (*Triticum aestivum* L.) is a source of staple food more than 36% of the global population. Wheat plant is highly sensitive to abiotic stress such as elevated temperature, drought etc. especially at flowering and grain filling stages. It severely affects the normal Growth, photosynthesis, metabolic processes, nutrient assimilation, and ultimately results in the reduction in overall wheat yield. The responses of wheat to these abiotic stresses are varied at morphological, physiological, molecular, and biochemical levels. It is very important to evaluate and quantify the various physiological trait associated with heat tolerance. Technology has been advanced and now the instruments based on the physiological principle has been developed. Physiological traits such as canopy temperature measurement using infrared based temperature detection system, stomatal conductance measurement using porometer for the transpiration rate measurement and hence water loss, chlorophyll fluorescence (CFL) measure the photosynthesis efficiency, chlorophyll content measurement in intact plant using chlorophyll meter (SPAD), Normalized difference vegetation index (NDVI), which is a measure of leaf greenness (chlorophyll content) sensor. These instruments are technically advance, user friendly made up of durable material and not very labor intensive. Moreover, these methods provide direct measurements and data recording facility which can be easily converted into graphs etc. the most useful advantage is they are non-destructive method of measurement and thus there is no requirement of usage of chemical and laborious instrumentation facility. In brief, these instrument based on the modern technology have greatly facilitated the measurement of various traits in wheat as well as other crops which has really facilitate the researcher to record and analyze important trait data with ease with accuracy and draw the conclusions on the basis of this data is a great help for the researchers to predict select the potential wheat drought and temperature stress tolerant wheat varieties which can withstand the water and heat stress for the wheat growing areas where temperature remain high and irrigation facilities are not available. These varieties will be able to survive and yield better with minimum usage of water resources for irrigation and can ensure the livelihood security of the farmers.

Keywords: *Climate Change, Technological Advancement, Physiological Traits, water and heat stress, water resources, livelihood security.*

Climate Smart Approaches for Soil-Water Conservation and Management in the Temperate Mountainous Ecosystem of part of Western Ghats, India

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Climate change and extreme weather events affect soil and watershed hydrology and have a long term influence on ecological processes. Because of unpredictable nature of climate change, it becomes more vulnerable to manage and preserve soil and biodiversity. In recent years, the gap between water supply and demands has widened and the demand of water for irrigation has been increasing due to climate change and frequent occurrence of extreme weather events like drought and floods. Therefore, it is essential to adapt climate resilient agriculture and to solve potential water resources problems for human's existence and well-being. It is significant to note that the global mean surface temperature has increased more rapidly about 0.18°C per decade in last 25 years, with the last decade (2001–2010) being the warmest decade on record. Our efforts to understand specific impacts of climate change on soil-water and agriculture, remains inadequate in highly sloping hilly region of Nilgiris where runoff from rainfall events is more than 95 per cent. Therefore, it is imperative to implement water harvesting structures like ponds besides conserving natural ponds. Also, soil conservation measures like bench terracing, contour bunding, vegetative barriers etc., need to be implemented to protect and conserve our precious soil from runoff. Also, frequent changes in land use practices especially conversion of swamps and forests to agricultural activities accelerate carbon di oxide (CO_2) emission and aggravates global warming impacts. Therefore, the present paper evaluates the role of climate change on soil and watershed, hydrology at a regional scale and discusses alternative mitigation strategies through efficient climate smart agriculture, soil and water resources planning, integrated water resources management, climate modelling and projections with emphasize on climate smart agriculture and preservation of biodiversity in the fragile temperate mountainous ecosystem of Nilgiris.

Keywords: *Biodiversity, Climate Change, Soil Conservation and Management, Weather extreme events*

Soil Carbon to mitigate climate change

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Carbon sequestration is the process of capture and long-term storage of atmospheric carbon dioxide (CO_2) in a stable state. This process can be direct or indirect, and can be biological, chemical, geological, or physical in nature. When inorganic CO_2 is sequestered directly by plants through photosynthesis or through chemical reactions in the soil, this process is often called "carbon fixation". Biological processes that occur in soils, wetlands, forests, oceans, and other ecosystems can store CO_2. These uptake mechanisms are sometimes called "carbon sinks."When carbon is sequestered directly in the soil, inorganic chemical reactions convert CO_2 into inorganic carbon compounds such as calcium and magnesium carbonates. Direct carbon sequestration occurs in plants as they photosynthesize atmospheric CO_2 into biomass, which means it is stored in "sinks" instead of being released into Earth's atmosphere. Subsequently, some of this plant biomass is also indirectly sequestered as soil organic carbon (SOC) during decomposition processes. The amount of carbon sequestered is determined by several factors, such as soil and vegitation types, successional stages, and productivity dynamics – it can be difficult to determine, but in general, the total sequestration calculation reflects the long-term balance between carbon uptake and release mechanisms. Carbon sequestration has been cited as one of the potential strategy for the removal of the green house gases which are present in the atmosphere. One of the problems the agricultural system is facing is the sharp and the steep decline in the soil fertility, the main reasons behind this being the soil erosion and the loss of the soil organic matter. Moreover the turnover rate of the organic matter is very high in some region. Majority of the ecosystem they have lost around 30–40t C per ha and thus they have very high potential to sequester carbon. According to recent studies, most of the soils they have the tendency to sequester 20–50 t C per ha which can be in the undisturbed form some 20–50 yrs. The land and the land use changes have induce changes in the carbon stock. Carbon sequestration in the agricultural soil gives a sustainable outcome.

Keywords: *Soil carbon, Climate change, Carbon sequestration, vegetation*

Evaluation of reproductive profiling of Amur carp with special reference to different types of feed

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Proper nutrition is one of the most important factors influencing the ability of fishes to attain the genetic potential for growth, reproduction and longevity. Food quality and quantity affect fish reproduction. Adequate protein is essential for egg development, spawning, formation of follicles, ovarian tissues, growth and development of embryo. Dietary protein significantly affects fertility, gonad maturation, fecundity, hatching and viability of fish eggs and larval growth. Egg size and composition are useful indicators of seed production in terms of hatchability and larval quality. The present study was conducted to evaluate the effect of individual ingredient of feed on the serum biochemical parameters and hormones *viz* estrogen & testosterone of male & female of amur carp. Three diets were prepared *viz* high protein, lipid and carbohydrates separately & fed to the experimental species. The eight months study revealed that the high protein and lipid diet showed better results in all aspects evaluated. Feed conversion ratio, feed conversion efficiency, ova diameter, gonadosomatic index, hepatosomatic index, were also studied.

Keywords: *Nutrition, Reproduction, Gonad maturation, Amur carp*

National Web- Conference *on*
Technological Approaches for Resource Conservation and Management for Environmental Sustainability (TARCMES)
August 16 & 17, 2020
Organized by: **Academy of Natural Resource Conservation and Management, Lucknow (UP)**

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Programme

August 16, 2020	
10.00-10.05	Welcome Address by **Dr. Atul K. Singh**, President, ANRCM
10.05-10.10	About ANRCM by **Dr. Sanjay Arora**, Secretary
10.10-10.15	About National Web Conference by **Dr. Vikas Sharma**, Organizing Secretary
10.15-10.30	Inauguration of Web-Conference and **Inaugural Address** by **Dr. G. B. Singh**, Chief Patron, ANRCM; Ex-DDG (NRM), ICAR, New Delhi & Ex-VC, JNKVV, Jabalpur
PLENARY SESSION	
	Chairman: **Dr. D.K. Sharma**, Ex-Director, ICAR-CSSRI, Karnal, Haryana ***Co-chairman:*** **Dr. K. Rajan**, ICAR-IISWC, RC, Udhagamandalam ***Convener:*** **Dr. Ratna Sahay**, KVK Unnao
10.30-10.50	***Keynote Speaker*** **Dr. R.P. Singh**, VC, SKRAU Bikaner, Rajasthan
10.50-11.10	***Keynote Speaker*** **Dr. Ch. Srinivasa Rao**, Director ICAR-NAARM, Hyderabad ***Topic:*** *Resource Conservation Technologies for Sustainability of Agriculture and Environment in India*
11.10-11.30	***Plenary Speaker*** **Dr. B. Gangwar**, Ex-Director, ICAR-IIFSR, Modipuram, U.P. ***Topic:*** *System based resource management for ensuring livelihood security and environment sustainability*
11.30-11.50	***Plenary Speaker*** **Dr. G. Gururaja Rao,** Head/Joint Director (Retd), CSSRI, RRS, Bharuch, Gujarat ***Topic:*** *Coastal saline soils of Gujarat – Problems, reclamative measures and management*
11.50-12.10	***Keynote Speaker*** **Dr. S.S. Singh,** Director Extension, RLBCAU, Jhansi, U.P. ***Topic:*** *Climate change and it's mitigation practices in Eastern India*
12.10-12.30	***Keynote Speaker*** **Dr. S.K. Sharma,** Zonal Director Research, MPUAT, Udaipur, Rajasthan ***Topic:*** *Organic farming for resource optimization – The way forward*
12.30-12.35	Vote of thanks by **Dr. N.K. Pareek**, Organizing Secretary

TECHNICAL SESSION- I
Environmental Conservation and restoration of ecological balance

Chairman: **Dr. Y. P. Singh**, ICAR-CSSRI, RRS, Lucknow
Co-chairman: **Dr. Sanjay Swami**, CAU, Barapani
Conveners: **Dr. A.S. Yadav**, UPCAR, Lucknow; **Dr. Tarun Adak**, ICAR-CISH, Lucknow

12.35-13.30 **Oral Presentations**

S. No.	Oral	Authors	Presenting Author
1.	Effect of forest land covers on soil organic carbon stocks in southern hilly region	K. Rajan, R. Ragupathy and P. Raja	K. Rajan
2.	Efficacy of Kafal (*Myrica esculanta*) leaves extract as bioadsorbent in reducing copper ion concentration from aqueous solution	Kusumlata Goswami and R. N. Ram	Kusumlata Goswami
3.	Farming system approach for food security and	Sundar Anchra,	Sundar Anchra

	sustained rural economy	M.K.Kaushik, Sonal and Manish Bera	
4.	Mitigating leaching loss of calcium through foliar nutrition	Giffy Thomas, Adarsh S. and Vandana Venugopal	Giffy Thomas
5.	Nesidiocorus an emerging pests of sesame	V. S. Acharya and Keshav Mehra	V. S.Acharya
6.	Solar based automatic water pumping system for agriculture purpose in upper hilly region of India	Monika Gairola and Shekhar Singh	Monika Gairola
7.	Bio-engineering measures for conservation of soil and water resources in North Western Himalayas	Deepak Singh	Deepak Singh
8.	Remote Sensing and GIS based quantitative morphometric analysis of thirteen sub-watersheds of Mand catchment Chhattisgarh using SRTM-DEM	Shreeya Baghel and Aekesh Kumar	Shreeya Baghel
13.30-14.00	**Poster Presentations**	***Convener***: Mr. Navneet Sharma	

POSTER PRESENTATIONS

TECHNICAL SESSION- I **Environmental Conservation and restoration of ecological balance**			
13.30-14.00 August 16, 2020	**Poster Presentations**		***Convener***: Mr. Navneet Sharma
1	**Crop Intensification with Pulses in Coconut Garden For Safeguarding Food Security In The State Of Kerala**	Pooja A. P.	Pooja A. P.
2	**Determination of Quantum Recharge Requirement by Utilizing Spatial Data for Revival of Kanari River**	Ayushi Trivedi and Manoj Kumar Awasthi	Ayushi Trivedi
3	**Ecological response to river sedimentation: ANN based approach**	Ashish Kumar and Vinod Kumar Tripathi	Ashish Kumar
4	**Evaluation of cow based organics for non-insecticidal pest management in castor**	G. V. Suneel Kumar and O. Sarada	G. V. Suneel Kumar
5	**Impact of weed management practices on weed indices and yield of Bajra Napier hybrid in Kerala**	Swathy A. H., Usha C. Thomas	SWATHY A.H
6	**Intensity of soil use and organic fractions in montanous ecosystem**	H. Sneha, K. Rajan, K. S Sujith, K. P. Aiswarya and P. Anith Robinson	Sneha. H
7	**Soil Organic Carbon Fractions in Fresh Water Swamps of Southern hilly Region**	P. Anith Robinson, K. Rajan, KP. Aiswarya, H. Sneha and KS. Sujith	Anith Robinson P
8	**Weed management in Bt cotton (*Gossypium hirsutum*) influences the yield through sequential application of herbicides**	Sreena K S and G. S. Yadahalli	Sreena K S
9	**Evaluation of reproductive profiling of Amur carp with special reference to different types of feed**	Mahima Tamta and R. N. Ram	Mahima Tamta
10	**Effect of organic manures on the growth of wheat and soil enzymatic activity**	Prerna Jetpariya and Sana A Kalyani	Sana A Kalyani
14.00-14.30	**Lunch Break**		

TECHNICAL SESSION- II Technological Options for Soil and Water Resource conservation and management ***Chairman:* Dr. T.K. Srivastava**, ICAR-IISR, Lucknow ***Co-chairman:* Dr. Anil Sharma**, ICAR-CPRI, RC, Jalandhar ***Conveners:* Dr. Mukesh Kumar,** IGNOU, New Delhi; **Dr. Shyamji Mishra**, CSSRI, RRS, Lucknow		
14.30-14.45	***Lead Speaker* Dr. D.M. Denis,** SHUATS, Prayagraj, U.P.	Using Remote Sensing and GIS for managing soil and water resources towards food and livelihood security
14.45-15.00	***Lead Speaker* Dr. M.S. Hadda,** PAU, Ludhiana, Punjab	Land uses in relation to soil physical characteristics and sustainability under semiarid irrigated conditions
15.00-17.00	**Oral Presentations**	

S. No.	Oral	Authors	Presenting Author
1.	Assessment of ground water quality for irrigation purpose in Bathinda district (Punjab, India)	Debjani Kundu and Anil Sood	Debjani Kundu
2.	Pit method an option for vegetable production in water logged sodic soils	Chhedi Lal Verma, Y.P. Singh, S.K. Jha, A.K. Singh, T. Damodaran, Sanjay Arora, V.K. Mishra and Rohit P. Ojha	Chhedi Lal Verma
3.	Deficit Irrigation : For reducing agricultural water use	Dhanu Unnikrishnan and L. Girija devi	Dhanu Unnikrishnan
4.	Development and performance evaluation of a human powered micro sprinkler system through a common Gym cycle utilizing the harvested surface water	JitendraSinha, BhaveshTiwari, BrijeshTirkey, Rifat Khan and NishaVerma	Jitendra Sinha
5.	Drip irrigation as one of the innovative techniques to conserve water and increase the productivity in sweet cherry.	Rehana Javid and W. M. Wani	Rehana Javid
6.	Effect of methods of land preparation on growth and yield of transplanted rice (*Oryza sativa*) in canal commands of North western plateau agro-climatic zone of Odisha - An on farm study	S. C. Senapati, J.K.Pati, A.P.Sahu, J. M. L. Gulati and S.K.Behera	S. C. Senapati
7.	GIS based spatial distribution and evaluation of water quality for irrigation purpose in Haridwar district	Sonali Kumara, Shekhar Singh and Vinod Kumar	Sonali Kumara
8.	Inherent fertility of Ratte Khera farm of Punjab Agricultural University, Punjab, India	Rajan Bhatt, Parmjit Singh and Sanjay Arora	Rajan Bhatt
9.	Mid Infrared Spectroscopy: A new technological and alternate option to conventional lab analysis for soil quality assessment	Debabrata Nath, Ranjan Laik and Santosh Kumar Singh	Debabrata Nath
10.	MOOCs on Water harvesting conservation and utilization	Mukesh Kumar and Vijayakumar, P. and Rohitashw Kumar	Mukesh Kumar
11.	Open dug well for increasing cropped area in hard rock area of Odisha	Ranu Rani Sethi, Madhumita Das, B. Panda and S. K. Ambast	Ranu Rani Sethi

12.	Options for improving crop water productivity in hot arid region	V.S. Rathore, N.S. Nathawat and N.D. Yadava	V.S. Rathore
13.	Performance of high yielding variety of sesame grow on raised bed in cluster front line demonstration under Bundelkhand condition	Shyam Singh and Diksha Patel	Shyam Singh
14.	Potential of different media based and floricultural crops grown vertical subsurface flow-Constructed wetland system for water stress mitigation	Paritosh Kumar, Harisha C.B., Neeraj Kumar, Kamlesh Kumar Meena, Ganesh Masal and Himanshu Pathak	Paritosh Kumar
15.	Studies on the effect of water regimes and organics on water saving, soil fertility and yield of rice (*Oryza sativa* L.)	Maheshwaran K.	Maheshwaran K.
16.	Subsurface drip irrigation for efficient fertilizer and water use in wheat crop- A case study	Ayushi Jha and Mukesh Siag	Ayushi Jha
17.	Impact of land use capability classes and present land use on soil properties and erodibility behaviour of Sheetalpur watershed of Hamirpur district of Bundelkhand region of Uttar Pradesh	Kaushal Kumar and Munish Kumar	Kaushal Kumar
18.	Development and Performance Assessment of Soil Moisture Sensors in Sandy loam and Laterite Soil	Navneet Sharma, Atul Kumar Singh and Abdul Hakkim, V.M.	Navneet Sharma
19.	Effect of different soil and water conservation practices on water quality in the adopted village ponds of north - western Himalayas	Vivak M. Arya, Vikas Sharma, Ajay Thakur and P.K. Rai	Vivak M. Arya
20.	Performance of Mole Drainage and its Economic Feasibility for Drainage of Irrigated Vertisols	Shrimant D. Rathod and Dilip K. Kathmale	Shrimant D. Rathod
17.00-17.30	**Poster Presentations**		***Convener***: Mr. Rohit P. Ojha

POSTER PRESENTATIONS

TECHNICAL SESSION- II

Technological Options for Soil and Water Resource conservation and management

17.00-17.30 August 16, 2020	**Poster Presentations**	***Convener***: Mr. Rohit P. Ojha

1	**Application of Modern Tools In Agricultural Water Management**	Blessy V A, Shiv Shanker Chaudhari	Blessy V A
2	**Assessment of Decadal Variability in Land use/Land cover using remote sensing and GIS**	Sumit Kumar and V.K. Chandola	Sumit Kumar
3	**Comparative evaluation of various NDVI models to estimate crop Co-efficient for Summer Sesame**	Nishad P. Pachani and M. H. Fadadu	Nishad P. Pachani
4	**Customized automated fertigation system for soilless media in proctected cultivation**	Kusum Pandey and K.G.Singh	Kusum Pandey
5	**Dynamics of drip irrigation to enhance crop water productivity**	Shiv Shanker Chaudhari and Blessy V A	Shiv Shanker Chaudhari
6	**Effect of different mulches on growth, yield and quality of banana cv. Grand naine**	Hanuman Nayak, M., Vijay Krishna, G. and Hameedunnisa Begum	G. Vijay Krishna
7	**Effect of soil and foliar application of manganese on wheat cultivars and manganese transformation in soil**	Shreyansh Mittal and Sat Pal Saini	Shreyansh Mittal
8	**Estimation and validation of empirical models for soil wetting front under point source of surface drip irrigation**	Dinesh Kumar Vishwakarma, Rohitashw Kumar	Dinesh Kumar Vishwakarma

9	**Evaluation of impact of shifting sowing date of rice-wheat crops on groundwater behavior in Indo-Gangetic plain of north-west India**	Vivekanand, Satyendra Kumar and Bhaskar Narjary, S K Kamra, AmeeshKhatkar, Suraj Goswami and Pavan Kumar Harode	Vivekanand
10	**Fixed Bed Column Adsorption of Organic Pollutants Using CZnO Nano Based Adsorbent Coated Sand Filter Bed for Dairy Industrial Effluent Treatment**	Dinesha, B. L., SharanagoudaHiregoudar., UdaykumarNidoni., Ramappa, K. T., Anilkumar Dandekar and Ravi, M. V	Dinesha B L
11	**Performance of artificial recharge structures in enhancing groundwater quantity**	Thiyagarajan, G., A. Raviraj and S. Panneerselvam	Thiyagarajan, G.
12	**Productivity of lowland rainfed rice (*Oryza sativa*) as influenced by establishment and weed management**	KevizhalhouKuotsu and Avanish Prakash Singh	KevizhalhouKuotsu
13	**Role of GIS and RS in natural resource management**	Vinothini R, Dhanalakshmi M, and Fahima fathima A	Vinothini R
14	**Soil and water conservation techniques**	Akshikabhawariya, Shankar Lal Sunda, Dr. N. K. Pareek	AkshikaBhawariya
15	**Solar powered automated drip irrigation system along with wireless sensor network technology : A solution for soil moisture stress- A review**	Golmei Langangmeilu and YengkhomLinthoingambi Devi	Golmei Langangmeilu
16	**Spectrum of technological options of soil -water conservation measures for sustainable agriculture**	Sartaj Ahmad Wani, Subhash Chand and Anil Sharma	Sartaj Ahmad Wani
17	**Water productivity enhancement in upland rice (*Oryza sativa* L.)**	Aparna R A, Jayakrishnakumar, V	Aparna R A
18	**Water testing & Quality of irrigation water**	Trilok Nath Rai, K. N. Rai , A.K. Rai, Anjali, Sadhna and S.K. Rai	Trilok Nath Rai
19	**Zero energy drip system for sustainable crop production in North Western Himalayas**	Deepak Singh	Deepak Singh
20	**Evaluation of Irrigation strategies using Water Evaluation and Planning Model (WEAP)for a Watershed in Bundelkhand Region, India**	Jyoti P Patil, V C Goyal and T Thomas	Jyoti P Patil
21	**Use of extrapolated saturated front widths of line source field dripper method for more reliable estimate of unsaturated hydraulic conductivity function**	Rohit Pratap Ojha, Cheedi Lal Verma, Derrick M. Denis and Sanjay Arora	Rohit Pratap Ojha
22	**Scientific approach for conservation of soil and water resources and its managements**	Jubuli Sahu, Sanjay Kumar Mandal and Shweta Kumari	Jubuli Sahu
23	**Bioremediation of soil and water resources by mushrooms for conservation and management of environment**	Julius Munna and Manish Kumar	Julius Munna/ Manish Kumar
24	**Conversion of line source saturated front to square source saturated front for measurement of unsaturated hydraulic conductivity**	Shubham Ojha, Chhedi Lal Verma, D.M. Denis and Rohit P. Ojha	Shubham Ojha
25	**Identifying hydrological response units (HRUs) for the west Banas river basin of Rajasthan state**	Jalgaonkar B. R., Mahesh Kothari, H. K. Mittal, P. K. Singh, H. K. Jain and N. L. Panwar	Jalgaonkar B. R.

August 17, 2020		
10.00-10.05	Welcome by **Dr. Vikas Sharma**, Organizing Secretary	
TECHNICAL SESSION- III **Agricultural diversification and technological interventions for livelihood security**		
	***Chairman:* Dr. A.K. Gupta**, SKNAU, Jobner ***Co-chairman:* Dr. Pradeep K. Rai, SKUAST, Jammu** ***Conveners:* Dr. Manoj K. Singh,** KVK Kausambi**; Dr. Awanindra K. Tiwari,** KVK Raebareli	
10.05-10.20	***Lead Speaker* Dr. Y.P. Singh,** ICAR-CSSRI, RRS, Lucknow	On-farm composting of municipal solid waste for restoration of degraded sodic lands and sustaining crop yield
10.20-11.35	**Oral Presentations**	

	Oral	Authors (In sequence)	Presenting Author
1.	Approaches for improving elevated CO_2 induced zinc reduction in rice	Ramireddy Bhavana, R. V. Manju, M.M. Viji, Beena R. and Mini C.	Ramireddy Bhavana
2.	Commercialization and diversification of Indian agriculture	Yogeshwari Sahu, Payal Vyas and Shashank Sharma	Yogeshwari Sahu
3.	Elite genotype (CA-4) of *Cassia auriculata* suitable for crop diversification, resource conservation through non-arable land cultivation to ensure livelihood benefits in semi-arid regions of Rajasthan	S.Kala, H.R.Meena, A.K.Singh, I.Rashmi and R.K.Singh	S.Kala
4.	Evaluation of Blackgram varieties under rainfed conditions of Chamarajanagar District, Karnataka	Sunil C M, Yogesh G S, Chandrakala Hanagi, Mohankumar A B, Abhishek P. S. and Rajath H. P.	Sunil C M
5.	Integrated Farming Systems –Action tool for livelihood security in tribal areas	Tejeswara Rao K., Suryakala K,Soujanya P., and Rama Rao G	Tejeswara Rao K
6.	Potentials of growing underutilized fruit crops in Kashmir for sustainability and nutritional security.	Rifat Bhat, Sharbat Hussain, Muzaffara Akhter, Umer Iqbal and M.M.Mir	Rifat Bhat
7.	Rebuilding Food and Soil Nutritional Security through Pulse Cultivation	Adarsh S., Giffy Thomas, Jacob John and Ameena M.	Adarsh S.
8.	Yield of different varieties of sugarcane	Trilok Nath Rai, K. N. Rai, Sadhna and S.K. Rai	Trilok Nath Rai
9.	*Murraya Koengii* possesses in vitro cytotoxic potential against lung cancer cells	Vikas Sharma, Shilpa Raina and Shashank K. Singh	Vikas Sharma
11.35-12.00	**Poster Presentations**	***Convener*: Ms. Divya Sahni**	

POSTER PRESENTATIONS

TECHNICAL SESSION- III **Agricultural diversification and technological interventions for livelihood security**			
11.35-12.00 August 17, 2020	**Poster Presentations** **Agricultural diversification and technological interventions for livelihood security**		***Convener*:** Ms. Divya Sahni
1	**Agricultural Diversification fortifying livelihood**	Gargi	Gargi

2	**Agricultural diversification through processing and value addition for livelihood security of rural youth**	Poonam Yadav, Ramesh Kumar and Jai Lal Yadav	Poonam Yadav
3	**Agricultural Diversification: Way of Increasing Sustainability of Agricultural Production System**	Shri Rakesh and Dr. N. K. Pareek	Shri Rakesh
4	**Agronomic Interventions in Agri-Horti Systems under Rainfed Conditions**	Meenakshi Gupta, Sarabdeep Kour and Vikas Gupta	Meenakshi Gupta
5	**Autotilling effects of potato cultivation: saving of energy, time and cost of production for next crop**	Sushrut Richa, Anand Kumar and Dr. Jitendra Bhaskar	Sushrut Richa
6	**Beneficial Insects and Perception of Rural Kashmiri Farmers on Significance of Insect Pollinators**	Naveena Nazim and Bilal Ahmad Bhat	Naveena NAZIM
7	**Capturing diversity in integrated farming systems prevailing in marginal households through quantitative farming system typology**	AnitrosaInnazent, Jacob D., Bindhu J. S., Brigit Joseph and Anith K. N.	AnitrosaInnazent
8	**Crop Diversification Options to Manage Rice-Fallow and to Catalyse Farm Productivity and Profitability in Odisha**	Anjali, V. Venkat Ramanan, Ajay Kumar Mishra and Sheetal Sharma	Anjali
9	**Cropping intensity management in Kushinagar**	Trilok Nath Rai, Ajay Ray, Anjali, S.S. Singh, R.P. Sahu, A.K. Dubey, A.K. Rai, K.N. Rai, S.K. Rai, Vikas Singh, Manimurugan, P. Devikar, M.L.Kushwaha, A.P. Singh, R.N.Prasad, Swati and J. Singh.	Trilok Nath Rai
10	**Designing and Evaluation of Low-Cost GPS based Integrated Solar Hammering Drum**	Sarita Mishra and Ajay Kumar Mishra	Sarita Mishra
11	**Diversification for nutritional and livelihood security in homegardens of southern Kerala – A case study**	Sheeba Rebecca Isaac, Bindu Podikunju and Arunjith P	Arunjith P
12	**Diversification of rice wheat cropping system for sustainability and livelihood security**	Sarita	Sarita
13	**ECG studies on gastroenteritis and urinary tract diseases affected dogs**	Moneesh Thakur, S.R. Upadhyay and Rajiv Singh	Moneesh Thakur
14	**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	S. K. Verma
15	**Effect of various planting geometry on the performance of topfeeds with and without intercrop**	Mubeena P, Usha C Thomas, Anita M.R.	Mubeena P
16	**Estimation of the magnitude and nature of Heterosis in hybrid rice (*Oryza sativa* L.)**	Nidhi Bhatt, M.K. Nautiyal and Ranjit Saroj	Nidhi Bhatt
17	**Evaluation of anthocyanin stability during storage of color extracts from Marigold (*Tagetes erecta* L.)**	Ranjeet K. Yadav and Mahesh Pal	Ranjeet K. Yadav
18	**Evaluation of efficacy of different fungicides and bio-agents against root rot of cluster bean caused by Macrophominaphaseolina**	Narender Singh, Manoj Kumar, R.S. Chauhan, J.L. Yadav and Rajpaul Yadav	Narender Singh
19	**Farmers' Behaviour towards Adopting Conservation Agricultural Practices in India**	Tannishtha Bardhan and Neelam bhardwaj	Tannishtha Bardhan
20	**GUM: By-product of rice bran oil refining**	Leena PreetiLakra, Hinachandrakar, Vedmani, Priyanka Netam	Leena PreetiLakra

21	**Homestead: an approach for sustainable living**	Namitha V V and Dr. K. Prathapan	Namitha V V
22	**Integrated farming systems for sustainability and enhancement of rural livelihoods – A review**	Jince Mary M. Joy and Jacob John	Jince Mary M. Joy
23	**Isolation and identification of Mycogoneperniciosa, causing wet bubble disease in Agaricusbisporus cultivation in Jammu**	Sardar Singh Kakraliya	Sardar Singh Kakraliya
24	**Post-Harvest technology and value addition in Phalsa (*Grewia subinaequalis*)**	Tribhuwan Singh Rajpurohit, Anupriya Sharma and Nitika Kumari	Tribhuwan Singh Rajpurohit
25	**Protected Cultivation: Boon for Farmers of Kashmir to Improve Livelihood**	Rishi Richa, Rohitashw Kumar, R.M. Shukla, Shakeel Bhat, Zeenat Farooq and Faizam	Rishi Richa
26	**Rainfall trend analysis by Mann- Kendall test for Bhubaneswer, Odisha**	Bhukya Srinivas, Dr.M.K.Tiwari	Bhukya Srinivas
27	**Screening of Chilli Varieties against insect pests Infestation**	Babita Bhatt and A.K. Karnatak	Babita Bhatt
28	**Training needs Assessment of Castor growers of Palanpur taluka of Banaskantha District (Gujarat)**	K.S.Patel and M.B.Gotatar	K.S.Patel
29	**Farming System Approach for Food Security and Sustained Rural Economy**	Sundar Anchra, M. K. Kaushik, Sonal and Manish Bera	Sundar Anchra
30	**Farmers Perception about Organic Farming in Rampur district of Uttar Pradesh**	Laxmi Kant and Navneet Sharma	Laxmi Kant

TECHNICAL SESSION- IV

Soil health, organic farming and nutrient management for sustainable productivity

Chairman: **Dr. V.K. Mishra**, ICAR-CSSRI, RRS, Lucknow

Co-chairman: **Dr. Sandeep Sehgal,** SKUAST-Jammu

Conveners: **Dr. Shefali Srivastava**, Environment Specialist NGP, Lucknow; **Dr. Manish Kumar**, Bihar

12.00-12.15	***Lead Speaker*** **Dr. Abdul Hakkim V.M.,** KAU, Kerala	Precision farming for natural resources conservation and management
12.15-13.00	**Oral Presentations**	

S. No.	Oral	Authors	Presenting Author
1.	Dissemination of microbial technologies for empowering rural weaker section	Astha Tiwari, Renu, D.P. Singh, Garima Rai, Rahul Kumar Gupta, Rajan Singh, Sudheer Kumar Yadav, Ashish Kumar Vishwakarma, Pooja Yadav, Vivek Singh, Khan Mohd. Sarim & Anil K Saxena	Astha Tiwari
2.	Effect of zinc and boron on growth, yield, bulb quality and nutrient uptake of Onion (*Allium cepa* L.) cv Bhima super under Mid-Central table land zone of Odisha, India	Meenakhi Prusty ,Niytyamanjari Mishra,Sunil Samal and Dibya Sundar Kar	Meenakhi Prusty
3.	Impact of frontline demonstrations on	Poornima Yadav P. I., Lekha .M,	Poornima Yadav P. I

	foliar application of 'Sampoorna KAU multi mix' in vegetable cowpea in the agroecological zone midland laterite of Kollam district for sustainable yield and income.	Tulasi.V, Saparia Sathyan	
4.	Foliar application of Sampoorna KAU Multi mix to address micronutrient stress	Thulasi, V., Moossa, P.P., Sureshkumar, P., Narayanankutty, M.C. and Purnima Yadav	Thulasi, V.
5.	Impact of long term fertilization on soil properties and Soybean productivity in a vertisol	Jalendra Bairwa, B.S. Dwivedi, A.K. Dwivedi and R.K. Thakur	Jalendra Bairwa
6.	Influence of organic amendments on soil properties and C sequestration potential of soil	Samanyita Mohanty	Samanyita Mohanty
7.	Influence of organic manures and bio fertilizers with level of nitrogen and phosphorus on soyabean	C. K. Desai, G. J. Patel and K. N. Rana	C. K. Desai
8.	Integrated Nutrient Management vs organic farming –lessons from permanent manurial trials	Thulasi, V., Summayya S, Moossa P P, Sandeep S and Muneshwar Singh	Thulasi V.
9.	Interaction effect of VAM with different amendments on increasing phosphorus uptake	K. Aswitha, T. Naveenkumar, V.R. Mageshen and M. Dhanalakshmi	K. Aswitha
10.	Nutrient release pattern of different fertilizer doses and IPNS	Mahesan V. R., Bagavathi Ammal U.and Pradip Dey.	Bagavathi Ammal
11.	Organic farming in horticultural crops for sustainable productivity	Prashant Joshi	Prashant Joshi
12.	Plant growth promoting activity of rhizobacteria	Upma Dutta, Tanika Mahajan and Arashdeep Kour	Upma Dutta
13.	Role of soil nutrients and germplasms conservation: need for soil nutrient indexing for better resource use efficiency	Tarun Adak and Kailash Kumar	Tarun Adak
14.	Smoke derived compound for plant growth and soil Health	Dhanalakshmi M, Rajalakshimi P. and Vinothini R. and Akila G.	Dhanalakshmi M
15.	Management of organic manures and bio-agents for organic cultivation of sugarcane	Om Prakash, Brahm Prakash and Pallavi Yadav	Om Prakash
13.00-13.30	**Poster Presentations**		***Convener***: Mr. Ravindra K. Gupta

POSTER PRESENTATIONS

TECHNICAL SESSION- IV Soil health, organic farming and nutrient management for sustainable productivity			
13.00-13.30 August 17, 2020	**Poster Presentations**		***Convener***: Mr. Ravindra K. Gupta
1	**Biofertilizer - A key player in enhancing soil fertility and crop productivity**	P.K. Rai, Vishal Gupta, Akash Sharma, G.K. Rai and Balbir Dhotra	P.K. Rai

2	**Effect of different cropping systems and tillage practices on yield of Indian mustard under rainfed conditions of Jammu**	Rajeev Bharat, Sunil Kumar Rai, Vivak M. Arya, A.P. Singh, Jai Kumar and Rahul Gupta	Rajeev Bharat
3	**Effect of organic and inorganic sources on nutrient availability and soil physio-chemical properties of apple orchard soil.**	Muzafar Mir, Ajay Gupta, S. S. Jamwal and Muneeshwar Sharma	Muzafar Mir
4	**Effect of Tillage Practices and Mustard based Cropping Systems on Soil Quality in Drylands**	Tanjot Kour and Sarabdeep Kour	Tanjot Kour
5	**Impact of different land use systems on size distributions and aggregates stability in the submontaneous zone of foothill Himalayas**	Vijay Kumar, K.R. Sharma, Vivak M. Arya and Vikas Sharma	Vijay Kumar
6	**Impact of different land uses on soil characteristics of Chandanwari micro-watershed of district Anantnag**	Haziq Shabir, Aziz Mujtaba, Aaamir Hassan and Gulzar Bhat	Haziq Shabir
7	**Impact of Land Use System and Seasonal Variations on Aggregate Associated Soil Carbon in Outer Himalayas**	Japneet Kour Kukal, Vivak M. Arya and Vikas Sharma	Japneet K. Kukal
8	**Impact of resource conservation techniques on runoff and sediment yield in lower shivaliks of Jammu**	Meena Yadav, Vivak M. Arya, Ajay Thakur and Divya Sharma	Meena Yadav
9	**Moisture influence on the soil microbial dynamics and microbial population**	Gulzar Ahmad Bhat, Haziq Shabir, Vivak. M. Arya and Shafat Ahmad Ahanger	Gulzar Ahmad Bhat
10	**Soil health, organic farming and nutrient management for sustainable productivity**	Davinder Paul Singh, K. R. Sharma, Vivak M Arya, Vikas Sharma	Davinder Paul Singh
11	**Status of major nutrients of Bhaderwah orchard under temperate condition**	Manoj Kumar, Neeraj Kotwal, Rohit Sharma, Sanjeev Kumar Choudhary, Mahital Jamwal, Vijay Kumar and Sarbdeep Kour	Manoj Kumar
12	**Studies on combinations of organic sources on productivity of rajmash (bush type) under high hills of Jammu**	Rohit Sharma, Neeraj Kotwal, Manoj Kumar, Vivak M. Arya, Sanjeev Kumar and D. K. Chaun	Rohit Sharma
13	**Sustainable soil health management in rainfed fruit production under changing climate scenario in shiwaliks foothills of Jammu and Kashmir, India**	Vijay Kumar, Rakesh Kumar, Manoj Kumar and Shalini Khajuria	Vijay Kumar
14	**A model for sustainable agriculture through organic farming in post Covid-19 scenario**	Shashank Sharma, Neha Khandey, Anjali Verma and Yogeshwari Sahu	Shashank Sharma
15	**Antimicrobial activity of phytoextracts of medicinal plants against plant pathogens**	Sakshi Baghat, Upma Dutta, Sonika Jamwal and Anamika Jamwal	Upma Dutta
16	**Carbon addition through residues in rice-rice cropping system under long term fertilizer experiment in an inceptisol of Bhubaneswar, Odisha**	Sipra Das, Shraddha Mohanty, R.K. Nayak and Bandita Jena	Shraddha Mohanty
17	**Crop residue management for improving soil organic carbon**	Amala Mary George, B. Sudha and Bindhya B.N	Amala Mary George
18	**Distribution of Available Silicon in Rice growing Soils of Jammu Plains**	Seema Pooniyan, Sarabdeep Kour and Vikas Sharma	Sarabdeep Kour
19	**Economic Analysis of Traditional Goat Rearing by Gurjars' Folks of Bharatpur District of Rajasthan, India**	V.S.Meena and UdaiBhan Singh	V.S.Meena

20	**Effect of Organic manures in Long Term Nutrient Management System on Yield, Quality and Soil Health in Finger Millet**	Sandhya Rani,Y., Jamuna, P., Triveni., Patro, T.S.S.K. and Anuradha, N.	Sandhya RaniY
21	**Effect of organic manures, bio fertilizers, level of nitrogen and phosphorus on growth and yield of soyabean**	C. K. Desai and G. J. Patel	C. K. Desai
22	**Effect of varying fertilizer doses and Soil Test Crop Response based Integrated Plant Nutrient System on quality and yield of Bhendi**	V.R. Mageshen, M. Dhanalakshmi, K. Ashwitha , T. Naveen Kumar and A. Pavithra	V.R. Mageshen
23	**Energetics of organic nutrition in direct seeded rice**	Nishan.M.A and Girijadevi.L	Nishan.M.A
24	**Enzyme activities in Mountain Hydromorphic soils under different Land uses**	Aiswarya K.P., K. Rajan, Anith Robinson P., Sujith K.S., Sneha H.	Aiswarya K.P.
25	**Impact of conjoint strategy of nickel and zinc application on soil nutrient status and microbial functions under low nickel soil**	Abhik Patra and Satish Kumar Singh	Abhik Patra
26	**Impact of potassium and K-biofertilizer on economics of potato (*Solanum tuberosum* L.)**	Amanpreet Singh	Amanpreet Singh
27	**Improved strategies for sustainable sugarcane and sugar production**	Satendrakumar S.P. Yadav S.C. Singh and Pratap Singh	Satendra Kumar
28	**Influence of lime, farmyard manure, wood ash and rice stubble management on nutrient availability and tomato yield**	Prantika Kakati, Anupama Das, Suravi Nandy and Nilay Borah	Prantika Kakati
29	**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	Manjul Kumar
30	**Land use effects on soil enzymes in high altitude region, The Nilgiris**	K.S. Sujith, K.Rajan, H. Sneha, P. Anith Robinson and K.P. Aiswarya	ks .sujith
31	**Mitogen Activated Protein Kinase (MAPK) signalling in plant disease resistance**	Suhail Altaf, ShaheenKousar Jan, Raheeba TUN Nisa	Suhail Altaf
32	**Nutrient availability in soil and tomato yield as influenced by compost sources and rice stubble management**	Anupama Das, PrantikaKakati, SuraviNandy and Nilay Borah	Anupama Das
33	**Nutrient uptake of container grown elephant foot yam as influenced by growth medium, nutrient schedule and irrigation schedule**	N P Limisha and O K Swadija	N P Limisha
34	**Organic farming and management effects on soil health**	P. Rajalakshimi, R.Vinothini , M. Dhanalakshmi and G.Akila	Rajalakshimi P
35	**Organic Farming and Nutrients Management for Sustainable Development**	Alok Patel, Shani Kumar Singh,	Alok Patel, Shani Kumar Singh,
36	**Organic pest control approaches against fruit flies towards sustainable productivity in Guava**	Visakh N.U and Shantanu Jha	VisakhN.U
37	**Precision Agriculture: Key to Mitigate the Adverse Effect of Climate Change**	Suraj Goswami, Shiv Ram Samota Vivekanand and Pawan Kumar Harode	Suraj Goswami
38	**Soil fertility effects of red gram [*Cajanus cajan* (l.) millsp.] under varying management practices in the southern laterites of Kerala**	Anjana Devaraj G and Sheeba Rebecca Isaac	Anjana Devaraj G
39	**Soil health and nutrient management for sustainable productivity**	Shankar Lal Sunda, Akshikabhawariya, Dr. R. K. Jakhar	Shankar Lal Sunda
40	**Soil organic carbon and its fractions as affected by integrated use of organic and fertilizer under**	Tajamul Islam Shah, M.P. Sharma, Vikas Sharma, Vivak	Tajamul Islam Shah

	blackgram of the foothill Himalayas	M. Arya	
41	**Technological intervention (Pruning) for sustainable productivity of nectarine cv snow queen**	Sharbat Hussain, Rifat Bhat, Khalid Rasool, Md Tauseef, Md Waheed, Aijaz Ahmed	Sharbat Hussain
42	**Tillering and number of millable canes pattern influenced by different fertility levels and variety in sugarcane**	Jai Prakash Singh, Sunderpal and Viresh Singh	Jai Prakash Singh
43	**Waste conversion efficiency of popular composting methods and characterization of various organic manures**	Geethu Jacob, Pooja A P, K C Manorama Thampatti	Geethu Jacob
44	**Availability of macro and micro nutrients in different four blocks of Moradabad district of Uttar Pradesh**	Manoj Singh, Ravindra Kumar, N.C.Tripathi, and A.K.Mishra	Manoj Singh
13.30-14.00	**Lunch Break**		

TECHNICAL SESSION- V **Climate smart approaches for sustainable management of natural resources** **Chairman: Dr. P.R. Bhatnagar**, ICAR-CSSRI, Karnal **Co-chair: Dr. Ranu Rani**, ICAR-IISWC, Bhuwaneshwar **Conveners: Dr. B.S. Dwivedi**, JNKVV, Jabalpur; **Dr. Deepak Singh,** ICAR-IISWC, Dehradun		
14.00-14.15	***Lead Speaker* Dr. A. Upadhyaya,** ICAR-RCER, Patna, Bihar	Prominent water management technologies for agricultural production
14.15-15.00	**Oral Presentations**	

S. No.	Oral	Authors	Presenting Author
1.	Climate Smart Approaches for Soil-Water Conservation and Management in the Temperate Mountainous Ecosystem of part of Western Ghats, India	P.Raja, K.Kannan, U.Surendran, K.Rajan and P.Mahesh	P. Raja
2.	Effect of different sowing environment and varieties on production potential of maize under central plain zone of U.P.	Naushad Khan, Ajay Kumar, S.N. Pandey, C.B. Singh and Shubham Singh	Naushad Khan
3.	Effect of mole drainage system on growth characters and Yield of Soybean in waterlogged Vertisols in Malwa region of Madhya Pradesh	S.S. Dhakad, K.V. Ramana Rao, G. R. Ambawatia and Kayam Singh	S.S. Dhakad
4.	Effect of pink pigmented facultative methylotrophs (PPFM) on yield attributes and yield of rice (*Oryza sativa* L.)	Aswathy J C., Shalini Pillai, P., Jacob John and K. S. Meenakumari	Aswathy J. C.
5.	Exploration of native lignocellulolytic actinobacteria and their evaluation as biodegrader of water hyacinth biomass	Patel M. H. and Patel H. K.	Patel H. K.
6.	Happy seeder technology for residue management in rice-wheat rotation	Priyanka Suryavansh, Munish Sharma, Harmeet Kaur and Yashwant Singh	Priyanka Suryavanshi
7.	Impact of climate resilient farming practices on food security during lockdown by COVID-19 pandemic in Odisha	Ajay Kumar Mishra and Sheetal Sharma	Ajay Kumar Mishra

8.	Impact of direct seeded rice on economics of paddy crop in Raebareli district	R. K. Kanojia	R. K. Kanojia
9.	Production of agri-biochar from pyrolysis of waste organic material and its utilization for acid soil management	Sanjay-Swami	Sanjay-Swami
10.	Technological advancements in water and heat stress tolerance related traits measurement in wheat	Surinder Paul, Joginder Singh Duhan and Ratan Tiwari	Surinder Paul
11.	Evaluation of irrigation strategies using Water Evaluation and Planning Model (WEAP)	Jyoti P. Patil , V. C. Goyal and T. Thomas	Jyoti P. Patil
15.00-15.30	**Poster Presentations**	***Convener***: Dr. Chandra Shekhar Singh	

POSTER PRESENTATIONS

TECHNICAL SESSION- V Climate smart approaches for sustainable management of natural resources			
15.00-15.30 August 17, 2020	***Poster Presentations***		***Convener***: Dr. Chandra Shekhar Singh
1	**Applications of Hydrological Models for Improved Irrigation Management in Changing Climatic Scenario**	Bheem Pareek and Nitesh Kumar	Bheem Pareek
2	**Soil Carbon Losses through Erosion as influenced by Conservation Agricultural Practices**	Divya Sharma, Vikas Sharma, Vivak M. Arya and Meena Yadav	Divya Sharma
3	**Artificial glaciers: A sustainable technique in conserving water crises in cold-arid region of Ladakh**	Stanzin Khenrab, Peeyush Sharma, Tenzin Topgyal	Stanzin Khenrab
4	**Soil Carbon to mitigate climate change**	Pradeep K. Rai, Vishal Gupta, Akash Sharma and Satish Sharma	Pradeep K. Rai
5	**Climate Smart Agriculture: Key to Sustainable Production and Food Security**	Sreeja, K., Mamatha Prabhakar, Anjaly C Sunny	Sreeja, K /Mamatha Prabhakar
6	**Growth and yield of rice (*Oryza sativa* L.) varieties as influenced by nutrient management under irrigated-aerobic condition**	Kiran Nayak, Koushik Sar and JML. Gulati	Kiran Nayak
7	**Soil erosion studies under simulated rainfall conditions in a lateritic terrain**	K. K. Praveena and E. K. Kurien	K K Praveena
8	**Tropical tuber crops: Potential future crops under the changing climatic scenario**	Anju B Raj ,Dr. Jacob John	Anju B Raj
9	**Water Management under changing climate**	Rajath, H. P., Yogesh, G. S., Jadeyegowda, M. and Adarsh, N	Rajath H P
10	**Livelihood promotion and nutritional security through soil and water resource & management in NICRA Village of Banka District**	Raghubar Sahu, Dharmendra Kumar, Manish Kumar and Raju Kumar	Dharmendra Kumar
11	**Studies on Physico – Chemical and biological properties of soil in different cropping sequences of ThakurdwaraTahsil of Moradabad district**	Ravindra Kumar, N.C. Tripathi, Manoj Singh and A.K. Mishra	Ravindra Kumar
12	**Prediction of Water Table Height in Response to Skewed Peak Recharge Rate Within Raised Bed of Integrated Farming System Model**	Gyan Singh, Chhedi Lal Verma and D.M. Denis	Gyan Singh
13	**Prediction of evapotranspiration using pan evaporation based geomatrical similarity model**	S.K. Singh and Chhedi Lal Verma	S.K. Singh

Poster Sessions *Chairman: Dr. Anshuman Kohli*

VALEDICTORY SESSION	
	Chief Guest: **Dr. U.S. Gautam,** Vice-Chancellor, Banda Agri. University, Banda
16:00-16:05	Welcome of Chief Guest by **Dr. Atul K. Singh**, President ANRCM & Chairman Org. Committee
16:05-16:10	Proceedings of the Web-conference by **Dr. Vikas Sharma**, Organizing Secretary
16.10-16.15	Report and Declaration of Awards by **Dr. N.K. Pareek**, Organizing Secretary
16.15-16.30	Address by ***Chief Guest*** **Dr. U. S. Gautam**, VC, BAU, Banda
16.30-16.35	Vote of Thanks by **Dr. Sanjay Arora**, Secretary, ANRCM & Convener
16.30-17.30	**G.B. Meeting of ANRCM**