Journal of Natural Resource Conservation and Management
Vol. 1, No. 2, pp 119-124, 2020
doi: 10.51396/ANRCM.1.2.2020.119-124

Low input organic *vis-a-vis* conventional inorganic management for wheat: an analysis of variation for yield and yield components

Neelam Bhardwaj[1,*], Jeevanjot Kaur[2] and Anjali[2]

[1]Rice & Wheat Research Centre, Malan, CSK Himachal Pradesh Agricultural University, Palampur-176062, Himachal Pradesh, India; [2]Department of Genetics and Plant Breeding, CSK Himachal Pradesh Agricultural University, Palampur-176062, Himachal Pradesh, India
**Corresponding author E-mail: neenabhardwaj@gmail.com*

Received : September 23, 2020
Revised : November 10, 2020
Accepted : November 12, 2020
Published : December 23, 2020

ABSTRACT

Organic farming presents contrasting conditions to inorganic input-based farming, and therefore availability of suitable varieties responsive to those specific conditions had been a big constraint in realizing its full potential. A study was conducted during 2017-18 under conventional inorganic (I) and low input organic (O) conditions at Experimental Farm, CSK HPKV, Palampur with the objectives to evaluate 15 diverse wheat germplasm lines for grain yield and other agro-morphological traits for genetic variation studies and to identify reliable selection criteria for low input organic conditions. In general, the mean and range for most of the traits were found to be lower under the low input organic system as compared to the high input chemical system. Seed yield per plant was significantly positively correlated with days to flowering, days to maturity, tillers per plant, and spike length under organic system and with plant height, tillers per plant, and 100-seed weight under high input chemical system. Based upon the correlation and path studies days to flowering, days to maturity, tillers per plant, and spike length were considered as target traits to improve wheat grain yield under organic input condition, while plant height, tillers per plant, and 100-seed weight were found important traits for selection under chemical input conditions. The traits exhibiting positive association with yield under chemical input conditions were found to be non-significant under organic conditions and this change in correlation patterns under the two different conditions was due to the influence of genetic interactions. Hence, the present study showed that exposure to organic inputs conditions may induce positive or negative correlation among traits due to the expression of new gene advocating thereby that a separate breeding program is required for breeding varieties for organic agriculture.

Keywords: Organic Agriculture, genetic analysis, wheat, chemical input system

INTRODUCTION

Green revolution in India was mainly realized with the introduction of high-yielding varieties of wheat and rice along with the use of high input responsive varieties. With the introduction of semi-dwarf varieties during mid-1960's, India has made spectacular progress in the production during last few decades i.e. from 8.41 in 1950-51 to 17.38 million tonnes in 2014-15 (ICAR, 2016) enabling the country to become self-sufficient in food grains. The country has exported 2,35,699.04 million tonnes of pulses to the world for the worth of Rs.1,533.69 crores during the year 2019-20 (APEDA, 2020).The yield of the crops using high-yielding varieties integrated with high inputs has reached a plateau, but valuable soil nutrients are destroyed due to excessive and imbalanced use of fertilizers and pesticides. They also affect the structural and functional properties of microbial communities in soil (Yang *et al*., 2000; Bohme *et al*. 2005) which causes greater depletion of micronutrient reserves in the soil, and thereby accentuated widespread deficiencies of micronutrients (Alloway, 2008).

A self-sustaining system of agriculture like organic farming may offer a solution to these problems in different agricultural ecosystems (Bhardwaj *et al.*, 2020). Organic farming is a sustainable low-input eco-friendly practice**.** It depends on management practices that conserve, maintain, and enhance 'ecological harmony'. The ever-growing problem of food security in the Indian rural economy can be mitigated by adopting the practices of organic farming. Low-input systems can be less damaging for the environment than conventional systems (Hossard *et al.*, 2016; Hussain *et al.*, 2019) but these systems have many challenges associated. One of the main challenges is developing varieties with the ability to achieve high yields under reduced chemical input systems and organic input conditions. The popularity of organic farming is increasing; however plant breeding concerns are a bottleneck in the further development of organic agriculture. At present, organic farming relies upon varieties produced by conventional plant breeding, albeit it demands varieties with different characteristics than the conventional varieties. As improved varieties are being produced without considering their ability to grow under low soil nutrient status and are selected for higher yields under high nutrient input conditions (Wissum *et al.*, 2009). Thus, it is important to choose the specific varieties according to the specific requirements and soil conditions.

In the developing countries like India, where organic movement is at the initial stage of development, varieties that are specifically bred for organic and low- input systems are almost negligible, whereas in developed countries approximately 95% of the organic agriculture is based on crop varieties that were specially bred for the conventional high-input conditions with selection in a conventional breeding program. Miko *et al.*, (2014) revealed that the selecting environment has distinct effects on the performance of bread wheat varieties under organic and low input growing conditions.

It has been observed that the important traits required under organic and low-input conditions are lacking in such lack varieties. This is mainly due to the reason that in conventional breeding programs, the selection is being carried out in the background of high inorganic fertilizer and crop protection inputs. Hence, in the present study, an effort has been made to find out important traits contributing to yield under organic *vis-a-vis* non-organic input conditions for selection under organic input conditions.

MATERIALS AND METHODS

The present study was conducted during 2017-18 under low input organic and high input chemical conditions at the Experimental Farm of the Department of Organic Agriculture & Natural Farming, College of Agriculture, Himachal Pradesh Agricultural University (CSKHPKV), Palampur (H.P.). Geographically, the farm is situated at an elevation of about 1,290 m above mean sea level with 36°6′N latitude and 76°3′E longitude representing the mid-hill zone (Zone-II) of Himachal Pradesh and is characterized by humid sub-temperate climate with high rainfall (2,500 mm per annum).

The experimental material comprised of 15 diverse wheat germplasm lines including some landraces and released cultivars of Northern Hill Zone. These 15 genotypes varying in their adaptability and yield potential were evaluated under conventional inorganic (I) and low input organic (O) conditions. The two sets of material were raised in a Randomized Block design with three replications. One set of the experimental material was raised in the organic block of the farm while another set was raised in the inorganic block on the same sowing date. Each plot consisted of four rows, each 3.0 m long with 23 cm spacing between rows. For the sowing of material under organic input conditions vermicompost @15t/ha whereas for non-organic sowing N: P: K @120: 60:30 was applied at the time of sowing.

The data were recorded on the traits, namely grain yield per plant (g), spikes per plant, spike length (cm), tillers per plant, 100- grain weight (g), plant height at maturity (cm), days to flowering, and days to maturity under both conventional inorganic and low input organic conditions. Observations were recorded on ten randomly chosen plants. The mean data were subjected to the genotypic, phenotypic, and environmental coefficient of variation which were estimated following Burton and De Vane (1953), and genotypic and phenotypic coefficient of variability as per Al. Jibouri *et al.*, (1958).At maturity, five guarded plants from each plot were selected at random for recording data on yield and yield components.

Before the commencement of the experiment, composite soil samples from 0-15 cm depth were

Table 1. Chemical characteristics of the experimental soil of organic and inorganic block.

	Organic block	Inorganic block	Analytical method employed
pH	4.5	4.7	1:2.5 Soil water suspension (Jackson,1973)
Organic carbon (%)	1.29	0.99	Wet digestion method (Walkley and Black,1934)
Available Nitrogen (kg/ha)	344.96	282.24	Alkaline permanganate method (Subbiah and Asija,1956)
Available Phosphorus(kg/ha)	24.64	20.16	Olsen's method (Olsen et al. 1954)
Available Potassium (kg/ha)	197.56	175.11	Ammonium acetate extraction method (AOAC, 1990)

collected from organic and inorganic blocks separately. The samples were analyzed for different chemical properties and the results of the analysis have been given in Table 1. A perusal of data showed that the soil of the experimental field was acidic under both conditions. The soil was rated high in organic carbon in organic input conditions whereas medium under chemical input conditions. The soils under both conditions were medium in nitrogen, phosphorus, and potassium.

RESULTS AND DISCUSSION

In general, the mean and range for most of the traits were found to be lower under organic input conditions as compared to high input (Table 2). Means were higher for plant height, days to flowering, days to maturity, plant height, tillers per plant, and seed yield under high input chemical system. On the other hand, mean values were higher in the low input organic system for spikes per plant, spike length, and 100-seed weight.

PCV and GCV values(Table 2) were observed to be high (>10%) for spikes per plant,100-seed weight, and seed yield under organic input conditions while moderate for plant height and spike length per plant under both organic and chemical input conditions(Table 2). The rest of the traits exhibited low PCV and GCV under both conditions. Higher estimates of heritability (>60%) were observed for days to flowering and maturity, seed yield under both the conditions and for tillers per plant, plant height, and 100-seed weight under organic conditions only. Moderate heritability (40-60%) was observed for spike length under both the conditions and, tillers per plant under chemical input condition. The remaining traits exhibited low heritability (<40%) under both conditions. The genetic advance was found to be high for seed yield under both the conditions and days to flowering under chemical input conditions only. High genetic advances coupled with high heritability were observed for seed yield per plant under both the conditions and days to flowering under chemical input conditions.

Table 2. Estimates of parameters of variability for various traits in wheat genotypes under organic and chemical input conditions

Traits		Mean ±S. E(m)	Range	PCV (%)	GCV (%)	Heritability h^2bs (%)	Expected GA
Days to flowering	I	119.00±3.95	106.67-131.3	4.91	4.83	96.84	12.00
	O	117.33±2.10	110.67-124.00	3.33	3.23	94.26	7.71
Days to maturity	I	170.50±4.19	167.00-174.00	1.29	1.25	93.53	4.26
	O	167.17±3.59	163.33-171.00	1.35	1.19	77.68	3.63
Plant height	I	98.13±1.41	85.47-110.80	7.93	4.08	26.46	4.15
	O	94.13±1.07	80.90-107.37	7.40	5.81	61.53	8.80
Spikes /plant	I	1.97±0.81	1.67-2.27	13.34	4.72	12.51	0.07
	O	2.33±0.67	1.53-3.13	19.09	10.57	30.68	0.29
Tillers/plant	I	38.00±0.97	31.40-44.60	11.71	8.50	52.66	5.10
	O	36.17±0.80	31.60-40.73	7.99	6.61	68.44	4.12
Spikelet length	I	16.40±1.21	14.63-18.17	7.19	4.87	45.94	1.14
	O	17.30±1.01	15.67-18.93	6.81	4.54	44.46	1.08
100-seed weight	I	5.86 ±0.34	4.62-7.10	14.69	8.40	32.65	0.56
	O	6.02±0.38	4.65-7.40	12.57	9.74	60.05	0.91
Yield /plot	I	492.50±6.07	328.33-656.67	20.34	17.75	76.15	148.92
	O	440.00±7.93	256.67-623.33	23.94	21.78	82.79	180.56

1. I= Inorganic 2. O= Organic

Correlation studies (Table 3 & 4) revealed that under organic input conditions seed yield per plant was significantly positively correlated with days to flowering, days to maturity, tillers per plant, and spike length. On the other hand under chemical input conditions, seed yield per plant was significantly positively correlated with plant height, tillers per plant, and 100-seed weight. Kumar *et al.*, (2014) observed a significant positive association of grain yield with days to flowering and maturity under chemical input conditions in wheat. Verma *et al.*, (2012) reported that grain yield of wheat) exhibited a significant positive correlation with effective tillers per plant, harvest index, and test weight at the phenotypic level and genotypic level. Days to flowering and maturity exhibited a significant positive correlation with plant height, tillers per plant, and seed yield under organic input conditions which was absent in chemical input conditions. Plant height exhibited a significant positive correlation with tillers per plant under chemical input conditions and with a 100-seed weight under organic input conditions. Tillers per plant had a significant positive correlation with spike length under organic conditions and with a 100-seed weight under chemical conditions. Significant positive correlations of seed yield with tillers per plant, grains per spike, biological yield, and harvest index under organic conditions in wheat were also reported by earlier workers (Bhardwaj *et al.*, 2014). Avinashe *et al.*, (2015) revealed that harvest index, biological yield per plant, and test weight were positively and significantly associated with grain yield per plant.

Correlation analysis has revealed some interesting facts about changes in input conditions. Exposure to organic input conditions can produce positive or negative correlations among traits due to the expression of new genes, the variances and covariances among traits are changed and correlation values show a congenial effect of organic input conditions that helps in selection among different traits under organic input conditions in making direct and indirect contributions of component characters towards seed yield. The negative correlation of seed yield with days to flowering and maturity under high input chemical system changed to significant positive under low input organic conditions while significant positive correlation of seed yield with 100-seed weight and plant height under chemical input conditions got transformed to significant negative under organic input conditions. Spike length was significantly positively correlated with yield only under the chemical input system. There is evidence that changes in conditions can influence genetic interactions among traits as well as genetic variance in traits themselves. Bhardwaj *et al.* (2012) made comparative studies on the correlation of yield and yield components under organic *vis-a-vis* non-organic input conditions in the wheat and found that correlation patterns under the two different conditions indicated the influence of genetic interactions.

The Association of various plant characters with the traits of major interest and economic importance like grain yield is the consequence of their direct and

Table 3. Estimates of correlation coefficients at phenotypic level for different traits under organic and chemical input conditions. (I=inorganic, O=organic)

Traits		Days to maturity	Plant height	Spikes/ plant	Tillers/ plant	Spike length	100- seed weight	Yield
Days to flowering	I	119.00±3.95	106.67-131.3	4.91	4.83	96.84	12.00	-0.561*
	O	117.33±2.10	110.67-124.00	3.33	3.23	94.26	7.71	0.386*
Days to maturity	I	170.50±4.19	167.00-174.00	1.29	1.25	93.53	4.26	-0.184
	O	167.17±3.59	163.33-171.00	1.35	1.19	77.68	3.63	0.323*
Plant height	I	98.13±1.41	85.47-110.80	7.93	4.08	26.46	4.15	0.280
	O	94.13±1.07	80.90-107.37	7.40	5.81	61.53	8.80	-0.076
Spikes/plant	I	1.97±0.81	1.67-2.27	13.34	4.72	12.51	0.07	0.054
	O	2.33±0.67	1.53-3.13	19.09	10.57	30.68	0.29	0.136
Tillers/plant	I	38.00±0.97	31.40-44.60	11.71	8.50	52.66	5.10	0.452*
	O	36.17±0.80	31.60-40.73	7.99	6.61	68.44	4.12	0.672*
Spike length	I	16.40±1.21	14.63-18.17	7.19	4.87	45.94	1.14	0.218
	O	17.30±1.01	15.67-18.93	6.81	4.54	44.46	1.08	0.426*
100- seed weight	I	5.86 ±0.34	4.62-7.10	14.69	8.40	32.65	0.56	0.312*
	O	6.02±0.38	4.65-7.40	12.57	9.74	60.05	0.91	-0.277*

*Significant at 5% level

Table 4. Estimates of direct and indirect effects at phenotypic level for different traits under organic and chemical input conditions. (I=inorganic, O=organic)

Traits		Days to flowering	Days to maturity	Plant height	Spikes/ plant	Tillers/ plant	Spike length	100- seed weight	Yield
Days to flowering	I	-0.53	0.01	0.01	0.01	-0.05	0.01	-0.01	-0.56*
	O	0.18	-0.04	-0.02	-0.03	0.28	0.04	-0.02	0.39*
Days to maturity	I	-0.26	0.02	0.00	0.00	0.04	0.00	0.02	-0.18
	O	0.13	-0.05	-0.03	-0.02	0.27	0.05	-0.02	0.32*
Plant height	I	-0.03	0.00	0.22	-0.01	0.08	0.00	0.02	0.28
	O	0.05	-0.02	-0.06	-0.01	0.04	0.00	-0.07	-0.08
Spikes/plant	I	0.06	0.00	0.01	-0.05	0.03	0.00	0.00	0.05
	O	-0.05	0.01	0.01	0.12	0.01	0.00	0.05	0.14
Tillers/plant	I	0.10	0.00	0.03	-0.01	0.28	0.00	0.05	0.45*
	O	0.09	-0.03	0.00	0.00	0.55	0.06	0.00	0.67*
Spike length	I	0.24	0.00	0.00	-0.01	0.00	-0.03	0.01	0.22
	O	0.04	-0.01	0.00	0.00	0.18	0.18	0.05	0.43*
100- seed weight	I	0.06	0.00	0.02	0.00	0.10	0.00	0.13	0.31*
	O	0.02	-0.01	-0.02	-0.03	-0.01	-0.04	-0.19	-0.28*

*Significant at 5% level

indirect effects. It, therefore, becomes essential to partition such association into direct and indirect effects of component characters through path coefficient analysis. In the present study, to obtain a relevant and clear understanding of the association and among various traits, the estimates of the direct and indirect effects at phenotypic and genotypic level was worked out under organic and non-organic environments. The positive correlation of seed yield with days to flowering, tillers per plant, and spike length under organic input conditions and plant height, tillers per plant and 100-seed weight under chemical input conditions was due to high direct effects. On the other hand, the positive correlation of days to maturity with seed yield was due to indirect effects via days to flowering and tillers per plant. Path analysis showed a high magnitude of direct effects for days to flowering, spikes per plant, tillers per plant, spike length, and 100-seed weight under organic input conditions and for plant height, tillers per plant only under chemical input conditions. Okuyama *et al*., (2004) also observed a positive direct effect of the number of spikes on grain yield under irrigated and non-irrigated conditions. Iftikhar *et al*., (2012) revealed that grains per spike had a positive direct effect on grain yield followed by plant height, grains per spike, and thousand-grain weight. Similar studies were also conducted by Sood and Sood, (2001) for the effects of cropping systems on some genetic parameters in soybeans and observed different criteria in each cropping system. Bhardwaj *et al*. (2012) made comparative studies on the correlation of yield and yield components under organic vis-a-vis non-organic input conditions in wheat and lentil and, found that correlation patterns under the two different conditions indicated the influence of genetic interactions. Exposure to organic inputs conditions may induce positive or negative correlation among traits due to the expression of a new gene (Manal, 2009), advocating thereby that a separate breeding program is required for both the conditions.

CONCLUSION

In the present study, it was observed that seed yield per plant was significantly positively correlated with days to flowering, days to maturity, tillers per plant, and spike length under the organic system which was due to the high direct effects of these traits. Similarly, the significantly positive association of seed yield with plant height, tillers per plant, and 100-seed weight under a high input chemical system was also due to the high direct effects at genotypic and phenotypic levels. Hence, days to flowering, days to maturity, tillers per plant, and spike length were found to be the target traits to improve wheat grain yield under organic input condition, while plant height, tillers per plant, and 100-seed weight were found important traits for selection under chemical input conditions. The results of the present study indicate that different selection parameters operate for seed yield improvement under both conditions. Thus, the traits *viz*; days to flowering, days to maturity, tillers per plant, and spike length are to be considered as selection criteria for high yield for low input organic conditions while plant height, tillers per plant, and 100-seed weight are important selection criteria for high input chemical conditions.

REFERENCES

APEDA. (2020). Agricultural and Processed Food Products Export Development Authority. http://apeda.gov.in/apedawebsite/SubHead_Products/Pulses.htm

Al-Jibouri, Miller N.A. and. Robinso H.F. (1958). Genotypic and environmental variances and covariances in an upland cotton cross of interspecific origin. Agronomy Journal, *50*, 633-637.

Alloway, B.J. (2008). Micronutrient deficiencies in global crop production. *Springer, New York*, pp 353.

AOAC. (1990). Official Methods of Analysis: Association of Analytical Chemists (16th Ed.). Arlington Virginia, USA.

Avinashe, H.A., Shukla, R.S., Dubey, N. and Jaiwar, S. (2015). Correlation and path analysis for yield and yield contributing characters in bread wheat (*Triticum aestivum* L.). *Electronic Journal of Plant Breeding 6*(2), 555-559.

Bhardwaj, N., Rana, V. and Saini J.P. (2012). Correlation analysis of yield and yield components in wheat under organic vis-a-vis inorganic input conditions. *Crop Improvement* (Special Issue). pp 253-254.

Bhardwaj, N., Saroch. T., Sharma, P., and Saini, J.P. (2014). Estimates of variability and correlations for quantitative traits in wheat (*Triticum aestivum* L.) under organic vis-a-vis inorganic input conditions. *Crop Research, 47*(1-3), 12-16.

Bohme, L., Langer, U., Bohme, F. (2005). Microbial biomass, enzyme activities and microbial community structure in two European long-term ûeld experiments. *Agriculture, Ecosystems & Environment, 109*, 141–152.

Burton, G.M. and DeVane, E.H. (1958). Estimating heritability in tall Fescue (*Festucaarundinacea)* from replicated colonal material. *Agronomy Journal*, *45*, 310-314.

Hossard, L., Archer, D.W., Bertrand, M., David, C., Debaeke, P., Ernfors, M., Jeuffroy, M. H., Munier-Jolain, N., Nilsson, C., Sanford, G. R., Snapp, S.S., Jensen, E.S. and Makowski, D. (2016). A meta-analysis of maize and wheat yields in low-input vs. conventional and organic systems. *Agronomy Journal, 108*(3), 1155-1167.

Iftikhar, R., Khaliq, I., Kashif, M., Ahmad, M.A. and Smiullah. (2012). Study of morphological traits affecting grain yield in wheat (*Triticum aestivum* L.) under field stress condition. *Middle East Journal of Scientific Research, 11*(1), 19-23.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Wall.Inc. Englewood Chiffs. New Jersey, USA. *Journal of Ecology, 63*, 995-1001.

ICAR-Indian Institute of Pulses Research. (2016). https://iipr.icar.gov.in/pdf/1.2_270615

Kumar, Y., Lamba, R.A.S. and Saharan, R.P. (2014). Genetic variability for different biometric traits in wheat (*Triticum aestivum* L.) under medium fertility conditions. *Electronic Journal of Plant Breeding, 5*(1), 71-76.

Manal, H. Eid. (2009). Estimation of heritability and genetic advance of yield traits in wheat (*Triticum aestivum* L.) under drought condition. *International Journal of Genetics and Molecular Biology, 1*(7), 115-120.

Miko, P., Loschenberger, F., Hiltbrunner, J., Aebi, R., Megyeri, M., Kovacs, G., Molnar-Lang, M. and Rakszegi, M. (2014). Comparison of bread wheat varieties with different breeding origin under organic and low input management. *Euphytica*, *199*, 69-80.

Okuyama, L.A., Federizzi, L.C. and Neto, J.F.B. (2004). Correlation and path analysis of yield and its components and plant traits in wheat. *Ciencia Rural, 35*, 1010-1018.

Olsen, S.R., Cole, C.V., Watanable, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soil by extraction by sodium bicarbonate. *USDA Circular, 930*, 19-23.

Sood, V.K. and Sood, O.P. (2001). Effect of cropping system on some genetic parameters in soyabean (*Glycine max* (L.) Merrill). *Indian Journal of Plant Breeding & Genetics, 61*, 132-135.

Subhiah, B.W. and Asija, G.L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science, 25*, 259-260.

Verma, A., Singh, R. and Kumar, A. (2012). Interrelationship studies among grain yield and its component characters in wheat (*Triticum aestivum* L.). *Trends in Bioscience,. 5*(3), 255-259.

Yang, Y.H., Chen, D.M., Jin, Y., Wang, H.B., Duan, Y.Q., Guo, X.K., He, H.B., Lin, W.X. (2011). Effect of different fertilizers on functional diversity of microbial ûora in rhizospheric soil under tobacco monoculture. *Acta Agronomica Sinica*, *37*, 105–111.

Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Science, 37*, 29-38.

Wissum, M., Mazzola, M., Picard, C. (2009). Novel approaches in plant breeding for Rhizosphere related traits. *Plant Soil*, *321*, 409-430.