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Genetic analysis of variation in rice (*Oryza sativa* L.) for yield and yield components under organic *vis-a-vis* chemical input conditions

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Abstract

The present study was undertaken during *Kharif* 2020 under conventional inorganic (E_1) and low input organic (E_2) conditions at RWRC, Malan with an objective to evaluate 40 diverse rice germplasm lines in RBD with three replications for grain yield and other agro-morphological traits for genetic variation studies and to identify reliable selection criteria for low input conditions. The mean and range for all the traits except days to flowering and days to maturity were found to be lower under low input organic system as compared to high input chemical system. The overall mean of the genotypes for grain yield was 9.58 g/plant in organic input system as against the mean value of 12.98 g/plant in chemical input system. The top performing genotypes in organic input system were HPR 2795, Desidhan, Jattu, Chohartu, Deval and Sukara Red while in chemical input system top yielders were HPR 2795, HPR 2911, IC 191886, Varun Dhan, Bhrigu Dhan, HPR 2720 and Sukara. Based upon the correlation and path studies days to flowering, days to maturity, total tillers per plant and effective tillers per plant were considered as target traits to improve rice grain yield under organic input condition, while plant height, total tillers per plant and 1000-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.

Key words: Organic Agriculture, genetic analysis, chemical input system, correlations

Green revolution in India was mainly realized with the introduction of high yielding semi dwarf varieties of wheat and rice with the use of high responsive fertilizers. With the introduction of semi dwarf varieties during mid 1960's, India has made a spectacular progress in the production during last few decades enabling the country to become self-sufficient in food grains. The yield of the crops using semi dwarf 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. This has caused greater depletion of micronutrient reserves in soil and thereby accentuated wide spread deficiencies of micronutrients (Alloway, 2008).

A self-sustaining system of agriculture like organic farming may offer solution to these problems in different agricultural ecosystems (Bhardwaj *et al*. 2020). Organic farming is basically a sustainable low-input eco-friendly practice. It is based on minimal use of off-farm inputs and on management practices that restore, maintain, and enhance 'ecological harmony'. The role of organic farming in Indian rural economy can be leveraged to mitigate the ever-increasing problem of food security. Hossard *et al*. (2016) concluded that low-input system could be less damaging for the environment than the conventional systems in reducing yield losses but this system is

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associated with many challenges and one of the main challenges is developing varieties with the capacity to achieve high yields in reduced chemical input systems /organic input conditions. As the popularity of organic farming is increasing, plant breeding concerns are however a bottleneck in the further development of organic agriculture. Currently, organic farming largely depends upon varieties supplied by conventional plant breeding, even though organic farming conditions demand varieties with the different characteristic than the conventional varieties. 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 nil, whereas in developed countries it is estimated that more than 95% of organic agriculture is based on crop varieties that were bred for the conventional high-input sector with selection in conventional breeding programme. It has been observed that such varieties lack important which are traits required under organic and low-input production condition. This is primarily due to selection in conventional breeding programmes 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 of rice contributing to yield under organic *vis-a- vis* in-organic input conditions for selection under organic input conditions.

Materials and methods

The present study was conducted during *Kharif* 2020 under low input organic conditions and high input chemical conditions at RWRC, Malan. The experimental material comprised of 40 diverse rice germplasm lines including local land races and released cultivars of Northern Hill Zone. These genotypes varying in their adaptability and yield potential were evaluated under conventional inorganic (E_1) and low input organic (E_2) conditions. The two sets of material were raised in Randomized Block Design with three replications. One set of the experimental material was raised in organic block of the farm while another set was raised in inorganic block on the same date of sowing. Each plot consisted of four rows, each 3.0 m long with 20 cm spacing between rows. Recommended package of practices for organic and conventional agriculture were followed for raising the crop in both the conditions. The data was recorded on yield and other contributing traits and was subjected to correlation analysis following Burton and De Vane (1953).

Results and discussion

A suitable variety is of utmost importance to harness the yield potential in any crop and for the best utilization of the resources (Sharma *et al*. 2014). Significant variation among the genotypes was observed for all the traits studied in the present investigation. The mean values for all the traits under study were lower in organic input system as compared to the high input chemical input system (Table 1 & 2). Grain yield/plant ranged from 9.70g- 20.53g with a mean of 12.98 g/plant in inorganic system while the range was from 6.08g-16.91g with a mean of 9.58g in organic system. 1000-grain weight ranged from 12.78g-30.73g with a mean of 19.71g in organic input system as compared to the inorganic system where range was 17.28g-35.23g with a mean of 24.36g. Similar trend was observed for plant height, spikelets /plant, total tillers/plant and effective tillers /plant with low mean and range values in organic input system as compared to chemical input system. The top performing genotypes in organic input system were HPR2795, Desidhan, Jattu, Chohartu, Deval and Sukara Red while in chemical input system top yielders were HPR 2795, HPR 2911, IC 191886, Varun Dhan, Bhrigu Dhan, HPR 2720 and Sukara. HPR 2901, IC 191886, Hatiali, Byla and Varun Dhan were poor yielders in organic input system while Phulpatas, Hatiali, IC-3131186, Naggar Dhanand Roda Dhan were the poor yielders in chemical input system. IC 191886 and Varun Dhan which were among the top yielders in chemical input system exhibited poor yield in organic input system (Table 1&2). Noori *et al* (2023) also observed differential response of different varieties of chilli and garden pea under conventional, organic and natural farming system.

Correlation studies (Table 3) revealed that under organic conditions grain yield per plant was significantly positively correlated with days to flowering, days to maturity, total tillers per plant and effective tillers per plant. On the other hand, under chemical input conditions, grain yield per plant was significantly positively correlated with plant height, total tillers / plant, effective tillers/plant, and 1000-grain weight. Days to flowering and maturity exhibited

Table 1: Mean performance of rice genotypes under organic input conditions

S.No	Genotypes	Days to 50% flowering	Days to 75% maturity	Plant height(cm)	Spikelets/ panicle	Total Tillers / Plant	Effective Tillers / Plant	1000-grain weight (g)	Grain Yield/ Plant(g)
1	Kaluna	78.00	108.33	87.84	50.85	6.00	5.21	16.1	8.85
2	Ramjuwain	81.00	108.00	119.74	52.92	7.00	6.00	17.74	7.81
3	Chohartu	81.33	110.00	146.20	37.95	8.00	7.00	23.47	13.68
4	Sukara	86.00	114.00	143.17	37.85	7.20	6.00	13.82	11.65
5	Karad	93.00	118.33	111.90	42.02	6.21	4.13	14.62	8.48
6	Kalaina	91.00	116.00	123.17	31.32	6.20	5.53	17.85	8.85
7	Phulpatas	76.00	105.00	102.7	47.45	5.41	4.20	15.64	9.28
8	Acchoo	90.33	117.00	144.77	39.39	5.20	4.13	16.74	9.61
9	Begmi	91.00	118.33	125.94	39.69	7.00	5.40	12.79	7.31
10	Bathidhan	79.00	108.00	112.00	40.15	7.43	6.73	23.6	10.41
11	Byla	85.00	105.33	136.64	32.29	6.20	5.70	19.7	6.71
12	Desidhan	88.00	116.00	138.57	27.35	7.20	6.00	18.24	15.35
13	Kalijhini-2	76.00	101.33	135.60	43.92	6.33	5.10	12.96	7.88
14	Sukara Red	91.33	120.67	130.04	57.29	6.23	5.00	22.02	13.21
15	Hatiali	89.00	109.33	123.64	32.65	5.37	4.60	17.23	6.15
16	HPR-2800	82.00	106.67	132.90	58.09	6.20	5.37	19.88	9.71
17	Naggar dhan	88.00	120.33	117.90	40.59	5.10	4.37	22.91	6.88
18	Roda dhan	73.00	102.00	123.17	47.35	7.43	6.13	24.85	6.95
19	Nailina	77.33	106.33	124.20	57.89	8.21	5.00	19.52	7.65
20	Deval	73.00	102.00	114.60	50.62	4.33	4.00	17.74	13.31
21	Bhrigu dhan	82.00	108.33	149.44	34.05	5.32	5.00	18.24	6.91
22	Kalijhini	79.33	106.67	125.87	35.15	6.21	5.33	13.95	12.61
23	Matali	86.00	110.33	92.50	42.89	5.77	5.00	18.04	8.71
24	Doda dhan	74.33	101.00	141.00	62.85	6.43	6.13	29.19	10.75
25	HPR 2902	86.00	108.33	156.27	49.92	4.83	4.13	19.88	7.58
26	Gosha	83.00	112.00	126.20	35.09	8.23	7.90	19.53	8.01
27	SailaDhan	77.67	102.00	135.80	50.12	7.10	6.83	23.51	11.05
28	Kalijhini	75.00	104.33	119.60	64.49	5.21	4.17	19.56	7.53
29	IC-191886	75.33	103.67	89.77	70.22	5.21	3.47	21.64	6.31
30	Jattu	74.00	101.00	87.74	72.82	6.23	5.00	21.4	14.49
31	Sattu Dhan	75.00	104.00	141.17	67.99	8.97	7.00	25.95	8.91
32	Kalijhini-1	77.33	105.33	124.74	51.35	8.21	6.97	12.78	9.36
33	IC-3131180	88.67	110.67	81.74	53.75	9.03	7.67	18.81	7.11
34	HPR-2901	102.00	130.33	90.40	44.75	7.23	6.23	20.01	6.08
35	HPR-2907	114.33	142.00	120.40	40.55	8.43	7.00	20.6	9.61
36	HPR-2911	108.33	133.00	79.20	34.02	7.21	6.70	24.7	8.88
37	HPR-2912	76.00	101.67	122.60	46.89	8.23	6.20	20.99	8.11
38	Varun Dhan	75.00	104.00	146.34	51.62	7.40	6.90	30.73	6.78
39	HPR-2720	96.00	126.67	127.27	55.82	10.27	8.20	19.82	10.81
40	HPR-2795	88.33	107.33	146.30	64.62	8.40	7.20	21.62	16.91
	Mean	84.07	110.89	122.48	47.41	6.80	5.72	19.71	9.58
	Max	114.33	142.00	156.27	72.82	10.27	8.20	30.73	16.91
	Min	73.00	101.00	79.20	27.35	4.33	3.47	12.78	6.08
	C.D	0.76	1.31	3.24	6.51	1.02	1.10	2.12	2.03
	C.V	1.20	0.72	4.51	7.52	5.41	9.20	6.50	4.78

Table 2: Mean performance of rice genotypes under chemical input conditions

S.No	Genotypes	Days to 50% flowering	Days to75% maturity	Plant Height(cm)	Spikelets/ panicle	Total Tillers/ Plant	Effective Tillers / Plant	1000-grain weight(g)	Grain Yield/ Plant(g)
1	Kaluna	82.00	110.67	98.07	64.13	10.37	10.17	20.60	13.47
2	Ramjuwain	79.33	109.67	129.97	66.20	6.30	6.13	22.24	11.43
3	Chohartu	77.67	108.00	156.43	41.23	3.67	3.60	27.97	12.30
4	Sukara	91.33	115.33	153.40	41.13	8.13	7.77	18.32	15.27
5	Karad	91.67	116.00	122.13	55.30	5.77	5.40	19.12	12.10
6	Kalaina	89.00	114.00	133.40	34.60	7.70	6.83	22.35	12.47
7	Phulpatas	76.33	106.67	112.93	50.73	6.73	6.53	20.14	9.70
8	Acchoo	91.33	115.00	155.00	52.67	4.57	4.13	21.24	13.23
9	Begmi	90.00	120.33	136.17	42.97	6.20	5.40	17.29	10.93
10	Bathidhan	75.33	105.00	122.23	53.43	4.33	3.73	28.10	14.03
11	Byla	77.00	107.33	146.87	35.57	5.50	4.70	24.20	10.33
12	Desidhan	89.00	121.33	148.80	40.63	8.90	7.90	25.74	8.97
13	Kalijhini-2	74.33	105.33	145.83	57.20	8.50	8.10	17.46	11.50
14	Sukara Red	93.00	123.67	140.27	70.57	7.83	6.70	26.52	10.83
15	Hatiali	88.00	111.33	133.87	45.93	8.37	7.60	23.73	9.77
16	HPR-2800	82.33	110.67	143.13	71.37	7.10	6.27	24.38	13.33
17	Naggar dhan	89.00	120.33	128.13	53.87	6.70	6.37	27.41	10.50
18	Roda dhan	71.67	102.00	133.40	60.63	9.10	8.57	29.35	10.57
19	Nailina	76.33	106.33	134.43	71.17	10.43	6.63	24.02	11.27
20	Deval	71.67	101.67	124.83	63.90	6.20	6.00	27.24	13.89
21	Bhrigu dhan	80.33	110.67	159.67	47.33	7.37	6.63	24.74	15.53
22	Kalijhini	77.33	108.67	136.10	48.43	7.87	7.33	18.45	13.23
23	Matali	88.00	112.67	124.63	56.17	6.23	6.13	22.54	12.33
24	Doda dhan	72.33	102.00	151.23	76.13	8.77	8.13	33.69	14.37
25	HPR 2902	84.00	111.33	166.50	63.20	5.43	5.13	24.38	11.20
26	Gosha	84.00	117.00	136.43	48.37	9.83	8.90	24.03	11.63
27	SailaDhan	75.67	101.67	146.03	63.40	8.17	7.83	28.01	14.67
28	Kalijhini	73.33	105.67	129.83	77.77	8.10	7.17	24.06	11.15
29	IC-191886	75.67	104.00	100.00	83.50	6.13	5.47	26.14	14.93
30	Jattu	72.33	102.00	97.97	86.10	8.23	5.43	25.90	13.11
31	Sattu Dhan	76.33	105.33	151.40	81.27	8.23	7.50	30.45	12.53
32	Kalijhini-1	76.67	106.67	134.97	64.63	7.97	4.97	17.28	12.98
33	IC-3131180	89.00	111.67	91.97	67.03	8.03	7.67	23.31	10.73
34	HPR-2901	101.33	132.33	100.63	58.03	8.10	7.73	24.51	12.90
35	HPR-2907	116.33	146.00	130.63	43.83	12.43	12.07	25.10	13.23
36	HPR-2911	106.33	136.00	89.43	37.30	9.07	8.70	23.20	19.50
37	HPR-2912	75.33	102.33	132.83	60.17	7.70	6.67	25.49	11.73
38	Varun Dhan	73.33	108.33	156.57	54.90	8.40	7.23	35.23	16.40
39	HPR-2720	94.00	124.33	137.50	59.10	8.27	8.20	24.32	15.43
40	HPR-2795	89.00	108.00	156.53	77.90	10.40	8.57	26.12	20.53
	Mean	84.69	112.18	133.25	58.19	7.68	6.90	24.36	12.98
	Max	116.33	146.00	166.50	86.10	12.43	12.07	35.23	20.53
	Min	73.33	101.67	89.43	34.60	3.67	3.60	17.28	9.70
	C.D	0.89	1.76	5.54	8.25	1.20	2.24	2.61	0.62
	C.V	2.10	0.88	3.12	8.30	6.53	8.65	6.30	7.23

Table 3. Estimates of correlation coefficients at phenotypic level for different traits under organic and chemical input conditions

Traits		Days to 75% maturity	Plant height	Spiklets/ plant	Total tillers/ plant	Effective tillers/ plant	1000- grain weight	Grain yield/ plant
Days to 50% flowering	E1	0.504*	0.067	-0.232	-0.153	-0.462**	-0.101	-0.491*
	E2	0.597*	0.281*	-0.296*	0.499**	0.118	0.116	0.282*
Days to 75% maturity	E1		-0.001	0.009	0.116	-0.034	0.156	-0.170
	E2		0.412*	-0.121	0.492*	0.310*	0.107	0.341*
Plant height	E1			0.121	0.301*	0.021	0.142	0.245*
	E2			-0.122	0.070	-0.001	0.347*	-0.061
Spikelets/panicle	E1				0.101	0.104	-0.005	0.072
	E2				0.021	-0.021	-0.256*	0.172
Total tillers/plant	E1					-0.001	0.342*	0.433*
	E2					0.362*	-0.009	0.615*
Effective tillers per plant	E1						0.036	0.250*
	E2						-0.265*	0.470*
1000- grain weight	E1							0.331*
	E2							-0.290*

E1=Inorganic E2= Organic; * Significant at 5% level

significant positive correlation with plant height, total tillers per plant andgrain yield under organic input conditions which was absent in chemical input conditions. Plant height exhibited significant positive correlation with total tillers per plant under chemical input conditions and with 1000-grain weight under organic input conditions. Total tillers /plant had significant positive correlation with effective tillers under organic conditions and with 1000-grain weight under chemical input conditions. Similar results of correlation analysis were also observed by Ratna *et al*. (2015), Tiwari *et al*. (2019) and Sadhana *et al*. (2022).

Table 4: Estimates of direct and indirect effects at phenotypic level for different traits under organic and chemical input conditions

Traits		Days to 50% flowering	Days to 75% maturity	Plant height	Spiklets/ plant	Total tillers/ plant	Effective tillers/ plant	1000- grain weight	Grain yield/ plant
Days to flowering	E1	-0.48	0.01	0.01	0.01	-0.04	0.02	-0.02	-0.491*
	E2	0.14	-0.02	-0.03	-0.04	0.24	0.01	-0.02	0.282*
Days to maturity	E1	-0.26	0.03	0.00	0.00	0.04	0.00	0.02	-0.170
	E2	0.13	-0.04	-0.03	-0.02	0.27	0.05	-0.02	0.341*
Plant height	E1	-0.03	0.00	0.18	-0.01	0.08	0.00	0.02	0.245*
	E2	0.05	-0.02	-0.05	-0.01	0.04	0.00	-0.07	-0.061
Spikelets/panicle	E1	0.06	0.00	0.01	-0.03	0.03	0.00	0.00	0.072
	E2	-0.05	0.01	0.01	0.14	0.01	0.00	0.05	0.172
Total tillers/plant	E1	0.10	0.00	0.03	-0.01	0.26	0.00	0.05	0.433*
	E2	0.09	-0.03	0.00	0.00	0.49	0.06	0.00	0.615*
Effective tillers per plant	E1	0.26	0.00	0.00	-0.01	0.00	-0.01	0.01	0.250*
	E2	0.04	-0.01	0.00	0.00	0.18	0.21	0.05	0.470*
1000- grain weight	E1	0.06	0.00	0.02	0.00	0.10	0.00	0.15	0.331*
	E2	0.02	-0.01	-0.02	-0.03	-0.01	-0.04	-0.20	-0.290*

E1=Inorganic E2= Organic; * Significant at 5% level

Correlation analysis has revealed some interesting facts about changes in input conditions. Exposure to organic inputs conditions may induce 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 will help in selection among different traits under organic input conditions, making direct and indirect contributions of component characters towards grain yield. The negative correlation of grain 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 grain yield with 1000-grain weight and plant height under chemical input conditions got transformed to significant negative under organic conditions. There are evidences that change in conditions can influence genetic interactions among traits as well as genetic variance in traits themselves. Bhardwaj *et al*. (2012) Bhardwaj *et al*. 2014 and Kaur and Bhardwaj (2019) made comparative studies on correlation of yield and yield components under organic vis-a-vis non-organic input conditions in wheat and gram and found that correlation patterns under the two different conditions indicated the influence of genetic interactions. Sharma *et al.* (2022) construed that morphological characters are largely influenced by the environmental factors.

Association of various plant characters with the traits of major interest and economic importance like grain yield is the consequence of their direct and indirect effects. It becomes, therefore essential to partition such association into direct and indirect effects of component characters through path coefficient analysis. The path coefficient analysis required to determining the degree of relationship between yield and its component effects, as well as for examining specific factors that contribute to a given correlation (Sekhon *et al*. 2019; Lata and Sharma 2023). In the present study, to obtain a relevant and clear understanding of the association among various traits, the estimates of the direct and indirect effects at phenotypic and genotypic level were worked out under organic and inorganic environments. The positive correlation of grain yield with days to flowering, total tillers/plant and effective tillers/plant under organic conditions and plant height, tillers/plant and 1000-grain weight under chemical input conditions was due to high direct effects. On the other hand, the positive correlation of days to maturity with grain yield was due to indirect effects via days to flowering and total tillers / plant. Path analysis showed a high magnitude of direct effects for days to flowering, effective tillers / plant and total tillers /plant under organic conditions and for plant height, total tillers / plant and 1000- grain weight only under chemical input conditions.

Conclusion

The results indicated that different selection parameters operate for grain yield improvement under both the conditions. Thus, the traits *viz*; days to flowering, days to maturity, total tillers per plant and effective tillers per plant are to be considered as selection criteria for high yield for low input organic conditions while plant height, total tillers / plant, effective tillers/plant and 1000-grain weight are important selection criteria for high input chemical conditions. 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 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 new gene (Manal 2009), advocating thereby that a separate breeding program is required for both the conditions.

Conflict of interest: The authors declare no competing interest.

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