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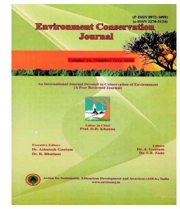

Evaluation of some genetic variability associated traits of 32 rice (*Oryza sativa* L.) genotypes in three different planting spacing by path coefficient analysis

Deepak Katkani ✉

Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur (Madhya Pradesh), India

Shiv Kumar Payasi

College of Agriculture, Rewa, JNKVV Jabalpur (Madhya Pradesh), India

Aidin Hamidi

Seed & Plant Certification and Registration Institute, Iran

Yogendra Singh

Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur (Madhya Pradesh), India

Rahul Patidar

Farm Production Officer, Sagar (Madhya Pradesh), India

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ABSTRACT

The study was taken up to estimate 32 advance breeding lines of rice for grain yield and the related traits in three different planting techniques, *viz.* direct seeded condition (E-I), transplanting with spacing of 15 x 15 cm (E-II) and 25 x 15 cm (E-III). The experimentation was carried out to explore the parameters of hereditary & variability for yield along-with yield components, to study the extent of association and direct and indirect special effects of different yield components on grain yield in rice. The analysis of variance from the experimental results documented significant changes amongst various genotypes for all studied traits with respect to the three planting spacing. High GCV, high magnitude of broad sense heritability coupled with genetic advance as percentage of mean was detected for grain yield/plant and harvest index. These above-mentioned traits displayed considerable contribution of different additive gene action for their phenotypic appearance. The characters harvest index (%), biological yield/plant, flag leaf angle and no. of productive tillers/plant showed positive correlation & direct effect on grain yield per plant on pooled analysis. It indicated that these traits might be included in formulating criteria of selection for enhancement of the grain yield per plant in rice.

Introduction

Rice (*Oryza sativa* L.) is the supreme cereal crop belonging to the genus of *Oryza*. Rice is the world second largest producing crop after wheat. Asia accounts for more than 90% rice production of world (FAO STAT, 2020). Rice designated as "Global Grain" (Pillai and Tulasi, 2008) for its usage as foremost essential food supplements in various developed and developing nations around the globe. Rice overfills the nutritious necessities of more than 50% of world's population. Genetic parameters such as genetic coefficient of variation (GCV), phenotypic coefficient of variance (PCV), heritability, genetic advance are important biometrical tools that are advantageous for measuring genetic variability. The achievement of any breeding improvement programme greatly be determined by the extent of variations available in that individual population and the assortment to which the appropriate traits were transferred. The significances of heritability will give advantage to the plant scientist to identify promising accessions for desired attributes and further efficaciously using that in our plant improvement programme. Direct selection through grain yield is not operative as it is governed by several polygenes and greatly affected by environmental fluctuations. To minimalize the

Corresponding author E-mail: *deepakkatkani157@gmail.com*
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environmental effects, it is needed to comprise qualitative traits which have significant positive correlation and direct effect on yield. The relative contribution of individual traits may be accomplished by correlation studies, Path coefficient analysis utilized to find out the direct and indirect causes of association governing the traits.

Material and Methods

The trial was performed at the area of Instructional Farm, College of Agriculture, Rewa (M.P.) during the season of *Kharif* in the year of 2018. The material contains of 32 advance breeding lines of rice. These lines were implanted in Randomized Block Design (RBD) with three replications with three planting spacing, *viz*. direct sowing: 4th July, 2018 (E- I), transplanting with spacing of 15 x 15 cm: 24th July, 2018 (E- II) and transplanting with spacing of 25 x 15 cm: 24th July, 2018 (E- III), (Katkani *et al.* 2021). Ten plants selected randomly from each replication and further observations documented for the traits *like,* plant height (cm), no. of tillers/plant, no. of productive tillers/plant, panicle length (cm), no. of grains per panicle, angle of flag leaf (^{0}), test weight (gm), biological yield/plant (gm), harvest index (%) and yield of grain/plant (gm) except for the trait days to 50% flowering and days taken to maturity. These two characters were noted on individual plot basis when more than half plants of one plot

Statistical analysis

Analysis of variance (ANOVA), Different genetic parameter of variation *like,* genotypic & phenotypic coefficient of variation, heritability, genetic advance as percentage of mean, Correlation coefficient and Path analysis were analyzed by using Windostat Version 9.[illegible]

Results and Discussion

The analysis of variance discovered that significant differences were recorded amongst the lines for all the traits in three planting spacing. It directed that among the considered advance lines satisfactory extent of genetic variability is existing for all the traits. Similar findings were also reported by Ajmera *et al.* (2017), Bhardwaj *et al.* (2017) and Katkani *et al.* (2021). The days to 50% flowering ranged from 65-106.3 days (91.0 mean) in E I, 66-86.0 days (73.2 mean) in E II, 59.6-83.6 days (72.5 days) in E III (table-1), days to maturity varied from 95.6-149.3 days (mean 124.1) in E I, 96.6-128.0 days (mean 112.8) in E II, 99-123.0 days (mean 111.6) in E III, the observed range of plant height was 61.6-120.40 cm (mean 82.2) in E I, 66.9-128.2 cm (mean 93.4) in E II, 68.6-128.2 cm (mean 92.8) in E III, number of tillers per plant found between 3.5-7.4 (mean 5.2) in E I, 5.3-12.0 (mean 8.3) in E II, 6.2-12.3 (mean 9.6) in E III, number of productive tillers per plant ranged from 1.4-7.1 (mean 3.5) in E I, 4.5-10.6 (mean 7.3) in E II, 5.7-10.9 (mean 8.7) in EIII, panicles length from 18.1-24.9 cm (mean 22.5) in E I, 19.4-28.7 cm (24.4 mean) in E II, 19.7-28.7 cm (mean 24.9) in E III, number of grains/panicle from 26-152.8 (86.3 mean) in E I, 1[illegible]7.1-200.5 (mean 147.6) in E II, 87.8-222.7 (mean 161.1) in E III, flag leaf angle ranged from 3[illegible]-76.3^0 (57.5^0) in E I, 37.7-83.0^0 (mean 63.[illegible]^0) in E II, 39.4-83.8^0 (mean 63.3^0) in E III, test weight ranged from 7.7-32.8 gm (17.8 mean) in E I, 13.6-24.1 gm (mean 18.8) in E II, 13.9-3[illegible]8 gm (mean 18.6) in E III, biological yield per plant from 9-27.6 gm (mean 16.9) in E I, 19.3-34.0 gm (mean 26.9) in E II, 17.5-38.0 gm (mean [illegible]1.0) in E III, harvest index ranged from 10.4-58.0 % (mean 22.7) in E I, 33-73.6 % (mean 49.0) in E II, 33.2-85.0 % (mean 60.2) in E III and grain yield per plant varied from 1.4-13.9 gm (mean 4.1) in E I, 6.8-20.0 gm (13.1 mean) in E II, 6-28.2 gm (mean 18.6) in E III. The genetic changeability that measures the distinctions existing in the population, subsequently it is an outcome of additive-fixable and non-additive genetic factor effects. These results were agreement with the findings of Rolando *et al.* (2016), Rashmi *et al.* (2017), Bharadwaj *et al.* (2017), Kumar *et al.* (2018), Sadimantara *et al.* (2018), Katkani *et al.* (2021).

Genetic parameter of variation:

The extent of genotypic and phenotypic coefficient of variation, heritability and genetic advance as percentage of mean were recorded for all studied characters are presented environment wise *like,* E-I, E-II and E-III in table 1 respectively. The genotypic coefficient of variation (GCV%) provides the information about the amount to genotypic variability standing in polygenic traits. The values of phenotypic coefficient of variation (PCV%) was slightly higher than genotypic coefficient of variation (GCV%) for all the traits in three planting spacing. It shown that environment does not play

Table 1: Parameters of genetic variability of morphological traits of E-I, E-II & E-III

Character	ENV	Range Lowest	Range Highest	Mean	GCV (%)	PCV (%)	h^2 (bs) %	GA as % of mean
Days to 50% flowering	E I	65.0	106.3	91.1	11.6	12.0	93.9	23.2
	E II	66.0	86.0	73.3	7.4	7.9	86.4	14.1
	E III	59.7	83.7	72.5	7.4	7.9	87.4	14.2
Days to maturity	E I	95.7	149.3	124.2	10.6	10.8	95.4	21.2
	E II	96.7	128.0	112.9	6.2	6.6	88.9	12.1
	E III	99.0	123.0	111.6	5.4	5.8	89.4	10.6
Plant height	E I	61.6	120.4	82.2	20.0	20.3	97.3	40.6
	E II	66.9	128.2	93.5	18.3	18.7	96.8	37.2
	E III	68.6	128.6	92.9	18.3	18.8	95.2	36.8
Number of tillers per plant	E I	3.5	7.4	5.2	20.5	22.2	85.0	38.9
	E II	5.3	12.0	8.3	17.7	19.7	80.9	32.9
	E III	6.2	12.3	9.6	15.5	18.3	71.5	27.0
Number of productive tillers per plant	E I	1.4	7.1	3.[illegible]	45.5	47.5	91.7	35.9
	E II	4.5	10.6	7.[illegible]	18.1	21.7	69.5	31.0
	E III	5.7	10.9	8.7	14.4	20.8	47.6	20.5
Panicle length	E I	18.1	24.9	22.5	7.4	8.1	85.4	14.2
	E II	19.4	28.7	24.4	7.6	8.3	84.4	14.5
	E III	19.7	28.7	24.9	8.3	9.2	81.4	15.4
Number of grains per panicle	E I	26.0	152.8	86.3	38.9	39.1	99.3	46.9
	E II	117.1	200.5	147.6	14.5	15.1	93.2	28.9
	E III	87.8	222.7	161.1	17.8	18.0	97.8	36.3
Flag leaf angle	E I	33.4	76.3	57.5	20.4	21.0	94.4	40.8
	E II	37.7	8[illegible].0	63.4	19.2	20.3	89.6	37.4
	E III	39.4	83.8	63.3	19.0	20.2	89.0	37.0
Test weight	E I	7.7	32.8	17.8	28.7	29.0	98.3	39.7
	E II	13.6	24.1	18.8	11.4	12.9	78.7	20.9
	E III	13.9	31.8	18.6	16.2	16.5	97.0	33.0
Biological yield per plant	E I	9.0	17.6	16.9	22.0	22.4	96.3	44.4
	E II	19.3	34.0	26.9	16.9	17.4	94.4	33.9
	E III	17.5	38.0	31.0	16.1	16.4	96.2	32.5
Harvest index	E I	10.4	58.0	22.7	58.8	59.5	97.9	52.7
	E II	33.0	73.6	49.0	20.0	20.6	94.1	40.0
	E III	33.2	85.0	60.2	26.0	26.5	96.6	52.7
Grain yield per plant	E I	1.4	13.9	4.1	77.3	77.9	98.4	61.7
	E II	[illegible].8	20.0	13.1	22.0	22.5	95.5	44.2
	E III	6.0	28.2	18.6	28.6	29.0	97.2	58.0

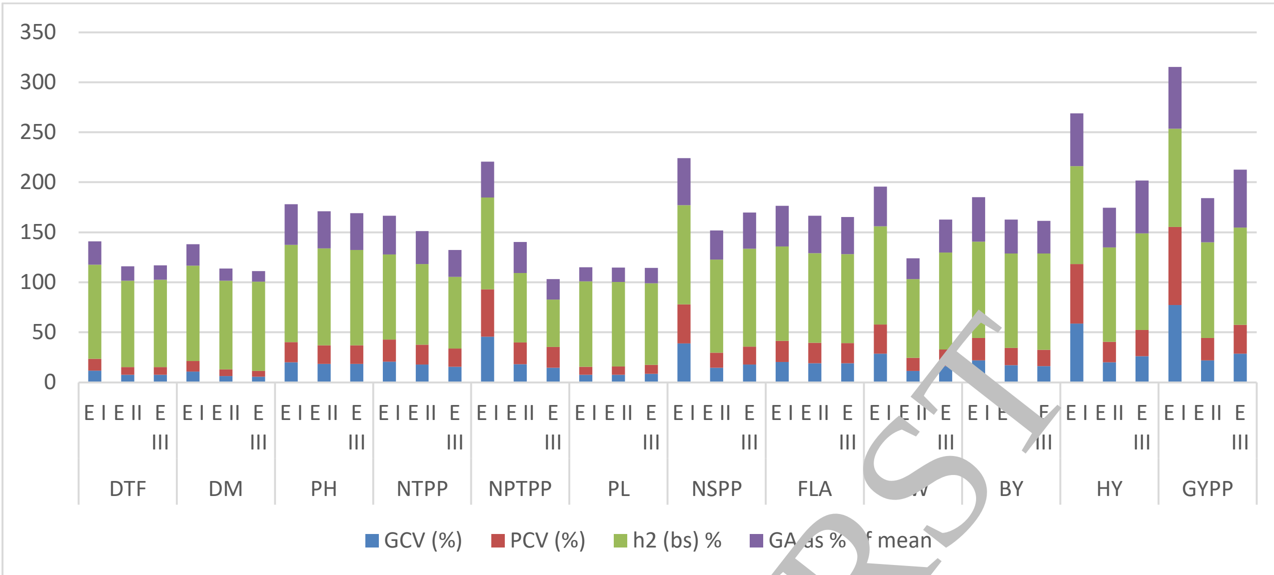

Figure 1: Genetic variability of quantitative traits in E I, E II & E III

significant role on the expression of these traits. The high degree of genotypic coefficient of variation (GCV%) and PCV% was detected for grain yield/plant (77.3%, 77.9%) followed by harvest index (58.8%, 59.4%), number of productive tillers per plant (45.4%, 47.5%), number of grains per panicle (38.9%, 39.0%), test weight (28.7%, 29.0%), biological yield/plant (22.[illegible]%, 22.4%), no. of tillers per plant (20.4%, 2[illegible]%) and flag leaf angle (20.3%, 21.0%) in E I, whereas the high magnitude of GCV% and PCV% was detected for grain yield/plant (22.0%, 22.5%) followed by harvest index (20.0%, 20.6%) in E II and high value of GCV and PCV (%) were recorded for grain yield/plant (28.5%, 29.0%) followed by harvest index (26.0%, 26.4%) in E III. On pooled analysis grain yield/plant and harvest index exhibited high amount of GCV % and PCV% (table-1, Figure 1). The presence of large amount of variability might be due to diversified source of materials as well as environmental fluctuations affecting the phenotypes (Ovung *et al.,* 2012) is an important element for selection and improvement of the crop. Similar kind of result's were also reported by Sritama *et al.* (2015), Sameera *et al.* (2016), Prasad *et al*. (2017), Manjunatha *et al.* (2017), Abebe *et al*. (2018).

The high range of heritability was detected for all the studied traits in E I, E II and E III, except for number of productive tillers per plant (47.1%) in E III. The high amount of genetic advance as percentage of mean were detected in E I, E II and E III for grain yield per plant (61.7%, 44.2%, 58.0%, respectively) followed by harvest index (52.7%, 40.0%, [illegible]%), number of grains per panicle (46.9%, 28.9%,36.3%), biological yield per plant (44.4%, 33.9%, 32.5%), flag leaf angle (40.8%,37.4%,37.0%), plant height (40.6%,37.2%, [illegible]%), test weight (39.7%, 20.9%,33.0%), number of tillers per plant (38.9%, 32.9%, 27.0%), number of productive tillers per plant (35.9%, 31.0%,20.5%). The above-mentioned outcomes were also supported by Chowdary *et al*. (2016) for grain yield per plant, Prasad *et al*. (2017) for number of grains per panicle, test weight, plant height, number of productive tillers per plant and number of tillers per plant, Rahman *et al*. (2015) for harvest index, Abebe *et al*. (2018) for biological yield per plant, Sameera *et al*. (2016) for flag leaf angle. These above discussed traits were disclosed extensive influence of additive & fixable special gene inter-action for their phenotypic countenance and via direct selection improvement in these traits might be possible. Heritability is the ratio of variation which is transmissible from one to next generation and results of heritability is helpful for breeder to select promising advance lines for desirable traits. Selection will be effective for the traits having high heritability coupled with high genetic advance. High GCV, high magnitude of broad heritability along-with GA were documented for the trait grain yield/plant and harvest index.

Table 2: Phenotypic correlation coefficient analysis of E-I, E-II & E-III

Character	ENV	DTF	DM	PH	NTPP	NPTPP	PL	NGPP	FLA	TW	BYPP	HI	GYPP
DTF	E I	**1**	0.960***	0.541***	-0.169	-0.446 ***	-0.274**	-0.317 **	-0.333 ***	-0.610 ***	-0.009	-0.593 ***	-0.510 ***
	E II	**1**	0.911 ***	0.096	0.061	0.083	-0.107	0.179	0.157	-0.141	0.150	-0.351***	-0.193
	E III	**1**	0.871***	-0.111	-0.167	-0.193	-0.249 *	-0.100	0.098	-[illegible]91	-0.318 **	0.151	-0.005
DM	E I		**1**	0.499***	-0.165	-0.381***	-0.293**	-0.272 **	-0.313 **	-0.57[illegible] ***	0.008	-0.556 ***	-0.463 ***
	E II		**1**	0.152	0.013	0.024	-0.102	0.266 **	[illegible].138	[illegible]0.045	0.153	-0.376 ***	-0.228*
	E III		**1**	-0.276**	-0.057	-0.091	-0.200 *	-0.224 *	-[illegible]	-[illegible].134	-0.302 **	0.090	-0.049
PH	E I			**1**	-0.077	-0.155	0.061	0.239 *	-0.269 **	[illegible]0.579 ***	0.437***	-0.212 *	0.541***
	E II			**1**	0.123	0.177	-0.011	0.10[illegible]	[illegible]0.134	0.061	0.110	-0.018	0.009
	E III			**1**	0.013	0.024	0.074	0.075	-0.236 *	0.016	0.381***	-0.055	-0.111
NTPP	E I				**1**	0.758***	-0.221 *	[illegible]010	[illegible]0.018	0.025	0.429***	0.366 ***	0.457***
	E II				**1**	0.951 ***	-0.152	-0.2[illegible] **	[illegible]0.013	-0.159	0.278**	0.077	0.277
	E III				**1**	0.927	0.375 ***	-0.199	-0.178	0.087	0.428***	-0.020	0.178
NPTPP	E I					**1**	0.085	0.[illegible]05**	0.171	0.368 ***	0.430***	0.619***	0.658***
	E II					**1**	-0.074	-0.312 **	-0.028	-0.095	0.313**	0.086	0.313
	E III					**1**	0.361***	[illegible].103	-0.168	0.202 *	0.442 ***	0.108	0.306
PL	E I						**1**	0.2[illegible]3**	-0.071	0.217*	0.003	0.120	0.110
	E II						**1**	-0.258 *	0.131	0.254 *	-0.022	0.2833**	0.236*
	E III						**1**	0.111	0.095	0.156	0.180	0.222 *	0.306 **
NGPP	E I							**1**	0.075	-0.138	0.378***	0.426***	0.440 ***
	E II							**1**	-0.013	0.0002	0.223 *	-0.320 **	-0.123
	E III							**1**	0.162	-0.079	0.292 **	0.412***	0.512***
FLA	E I								**1**	0.389 ***	0.122	0.295**	0.331 ***
	E II								**1**	0.300**	-0.047	0.063	0.052
	E III								**1**	0.276**	-0.255 *	0.326 **	0.177
TW	E I									**1**	-0.191	0.412***	0.297**
	E II									**1**	0.174	0.070	0.197
	E III									**1**	0.152	0.422 ***	0.476***
BYPP	E I										**1**	0.429 ***	0.673***
	E II										**1**	-0.261**	0.515***
	E III										**1**	-0.052	0.448***
HI	E I											**1**	0.939 ***
	E II											**1**	0.677 ***
	E III											**1**	0.857 ***

Where *, and *** significant at 5%, 1% and 0.1% level of probability, respectively**

DTF= Days to 50% flowering, DM= days to maturity, PH= plant height (cm), NTPP= number of tillers per plant, NPTPP= number of productive tillers per plant, PL= panicle length (cm), NGPP= number of grains per panicle, FLA= flag leaf angle (^{0}), TW= test weight (gm), BYPP= biological yield per plant (gm), HI= harvest index (%) and GYPP= grain yield per plant (gm)

Table 3: Phenotypic path analysis of E-I, E-II & E-III

Character	ENV	DTF	DM	PH	NTPP	NPTPP	PL	NGPP	FLA	TW	BYPP	HI	GYPP
DTF	E I	**-0.1701**	-0.1634	-0.0922	0.0289	0.0759	0.0467	0.0539	0.0567	0.1038	0.0015	0.1009	-0.5102
	E II	**0.0671**	0.0611	0.0065	0.0042	0.0056	-0.0072	0.0120	0.0106	-0.0095	0.0101	-0.0236	-0.1937
	E III	**0.0354**	0.0308	-0.0039	-0.0059	-0.0068	-0.0088	-0.0035	0.0035	-0.0068	-0.0113	0.0054	-0.0057
DM	E I	0.1498	**0.1560**	0.0779	-0.0258	-0.0595	-0.0458	-0.0426	-0.0488	[illegible]	0.0014	-0.0867	-0.4638
	E II	-0.0681	**-0.0748**	-0.0114	-0.0010	-0.0019	0.0077	-0.0199	-0.0103	0.0034	-0.0115	0.0282	-0.2284
	E III	0.0099	0.0114	-0.0031	-0.0007	-0.0010	-0.0023	-0.0025	[illegible]	-0.0015	-0.0034	0.0010	-0.0499
PH	E I	-0.0275	-0.0253	**-0.0507**	0.0039	0.0079	-0.0031	-0.0121	0.0137	0.0294	-0.0222	0.0108	-0.0781
	E II	-0.0052	-0.0083	**-0.0544**	-0.0067	-0.0097	0.0006	-0.0055	0.0073	-0.0033	-0.0060	0.0010	0.0091
	E III	0.0014	0.0035	**-0.0128**	-0.0002	-0.0003	-0.0010	[illegible]	0.0030	-0.0002	-0.0049	0.0007	0.1295
NTPP	E I	-0.0097	-0.0094	-0.0044	**0.0571**	0.0434	-0.0127	-0.0006	-0.0011	0.0014	0.0245	0.0209	0.4579
	E II	-0.0021	-0.0005	-0.0041	**-0.0331**	-0.0315	0.0051	0.0096	0.0004	0.0053	-0.0092	-0.0026	0.2776
	E III	0.0103	0.0035	-0.0008	**-0.0613**	-0.0569	-0.0231	0.0122	0.0109	-0.0054	-0.0263	0.0013	0.1789
NPTPP	E I	0.0130	0.0111	0.0045	-0.0221	**0.0291**	[illegible]	-0.0089	-0.0050	-0.0107	-0.0125	-0.0180	0.6584
	E II	0.0040	0.0012	0.0084	0.0451	**0.0475**	-0.0035	-0.0148	-0.0013	-0.0045	0.0149	0.0041	0.3139
	E III	-0.0071	-0.0033	0.0009	0.0339	**0.0365**	0.0132	-0.0038	-0.0062	0.0074	0.0161	0.0040	0.3062
PL	E I	-0.0141	-0.0151	0.0032	-0.0114	0.0044	**0.0513**	0.0135	-0.0037	0.0111	0.0002	0.0062	0.1109
	E II	-0.0003	-0.0002	0.0000	-0.0004	-0.0002	**0.0024**	-0.0006	0.0003	0.0006	-0.0001	0.0007	0.2363
	E III	-0.0107	-0.0086	0.0032	0.0161	0.0155	**0.0429**	0.0048	0.0041	0.0067	0.0077	0.0095	0.3067
NGPP	E I	0.0079	0.0068	-0.0059	0.0003	-0.0076	-0.0065	**0.0249**	-0.0019	0.0035	-0.0094	-0.0106	0.4408
	E II	0.0013	0.0019	0.0007	-0.0021	[illegible]	-0.0019	**0.0073**	-0.0001	0.0000	0.0016	-0.0023	-0.1231
	E III	-0.0020	-0.0045	0.0015	-0.0040	-0.0021	0.0023	**0.0202**	0.0033	-0.0016	0.0059	0.0084	0.5123
FLA	E I	-0.0212	-0.0199	-0.0171	-0.0012	0.0109	-0.0045	0.0048	**0.0636**	0.0248	0.0078	0.0188	0.3319
	E II	0.0037	0.0032	-0.0031	-0.0003	-0.0007	0.0031	-0.0003	**0.0232**	0.0070	-0.0011	0.0015	0.0520
	E III	0.0002	-0.0001	-0.0005	-0.0003	-0.0003	0.0002	0.0003	**0.0019**	0.0005	-0.0005	0.0006	0.1775
TW	E I	0.0114	0.0108	0.0108	-0.0005	-0.0069	-0.0041	0.0026	-0.0073	**-0.0187**	0.0036	-0.0077	0.2974
	E II	-0.0011	-0.0004	0.0005	-0.0013	-0.0008	0.0021	0.0000	0.0024	**0.0081**	0.0014	0.0006	0.1974
	E III	-0.0094	-0.0066	0.0008	0.0043	0.0100	0.0077	-0.0039	0.0136	**0.0492**	0.0075	0.0208	0.4760
BYPP	E I	-0.0032	0.0031	[illegible]	[illegible]	0.1529	0.0013	0.1345	0.0434	-0.0680	**0.3555**	0.1528	0.6738
	E II	0.1113	0.1141	0.0818	0.2064	0.2326	-0.0170	0.1659	-0.0352	0.1296	**0.7421**	-0.1943	0.5158
	E III	-0.1595	-0.1513	[illegible]	0.2142	0.2211	0.0903	0.1461	-0.1278	0.0761	**0.5002**	-0.0260	0.4480
HI	E I	-0.4465	-0.4185	-0.1596	0.2759	0.4662	0.0908	0.3206	0.2223	0.3107	0.3234	**0.7527**	0.9399
	E II	-0.3041	-0.3258	-0.0158	0.0668	0.0751	0.2450	-0.2767	0.0547	0.0609	-0.2264	**0.8646**	0.6778
	E III	0.1259	0.0753	0.0463	-0.0172	0.0906	0.1852	0.3433	0.2716	0.3515	-0.0432	**0.8318**	0.8574

E I R square = 0.9827, Residual effect = 0.1316, E II R square = 0.9806, Residual effect = 0.1394, E III R square = 0.9824, Residual effect = 0.1328

These traits can be additionally enriched by direct selection and considered for formulating selection criteria for further rice improvement programme.

Correlation coefficient represented the nature of association amid the characters. Grain yield/plant showed positive and significant relationship with harvest index (0.939) followed by biological yield per plant (0.673), no. of productive tillers per plant (0.658), plant height (0.541), no. of tillers per plant (0.457), no. of grains per panicle (0.440), flag leaf angle (0.331) and test weight (0.297) in E I, whereas grain yield per plant showed significant positive correlation with harvest index (0.677) followed *via.* Biological yield/plant (0.515) and length of panicle (0.236) in E II and harvest index (0.857) followed by no. of grains per panicle (0.512), biological yield/plant (0.448), test weight (0.476) and panicle length (0.306) in E III.

Based on pooled performance of all the environments, the yield of grains from individual plant depicted significant and positive association with the harvest index, biological yield/plant, no. of productive tillers per plant, plant height, no. of tillers/plant, no. of grains/panicle, flag leaf angle and test weight. Similar findings were also reported by Kumar *et al.* (2018) for biological yield per plant, Pandey *et al.* (2017) for number of tillers per plant and number of productive tillers per plant, Rashid *et al.* (2017) for plant height and number of grains per panicle, flag leaf angle and Archana *et al.* (2018) for test weight and harvest index. Hence, it can be concluded from this study that these traits should be considered as the selection criteria for improvement of grain yield per plant in rice.

Path coefficient analysis is a standard regression coefficient which split the measures of correlation into direct and indirect effect. Among twelve, eight traits presented positive direct effect (table-3) on grain yield/plant *viz.,* harvest index (0.752) followed by biological yield per plant (0.355), days to maturity (0.156), flag leaf angle (0.063), no. of tillers per plant (0.057), length of the panicle (0.051), no. of productive tillers per plant (0.029) and grains no./panicle (0.024) in E I, while harvest index (0.864) followed by biomass yield/ plant (0.742), days to 50% flowering (0.067), productive no. of tillers/plant (0.047), angle of flag leaf (0.023), test weight (0.008), grains no./panicle (0.007) and length of the panicle (0.002) in E II and the traits *viz.,* harvest index (0.831) followed by per plant biological yield (0.500), test weight (0.049), panicle length (0.042), productive no. of tillers/plant (0.036), no. of grains per panicle (0.020), days to mature (0.011) and flag leaf angle (0.001) in E III. Similar findings were also reported by previous scientists *like,* Bhujell *et al.* (2018) for test weight, harvest index, Kumar *et al.* (2018) for biological yield per plant, Rashid *et al.* (2017) for number of productive tillers per plant, Menaka *et al.* (2016) for number of grains per panicle, Dhurai *et al.* (2016) for days to maturity and flag leaf angle. The traits harvest index, biological yield per plant, flag leaf angle, panicle length and no. of productive tillers/plant had positive direct effect on grain yield/plant in pooled analysis. Thus, these characters appeared as most imperative direct contributor in the direction of the grain yield of rice. The traits depicting significant positive correlation and positive direct effect on grain yield per plant on pooled basis are harvest index, biological yield per plant, flag leaf angle, panicle length, test weight and number of productive tillers per plant. These diverse traits must be included in constructing plant architecture in different plant spacing environments.

Conclusion

The major goal of a plant breeder is to boost the genetic yield potential of the crop with high economic returns. In succeeding this objective, it is important to collect information based on genetic parameters of variability. The results depicted that wide-ranging variability were available for all the studied traits in three planting spacing. High range of GCV%, high heritability coupled with genetic advance was documented only for the trait harvest index and grain yield per plant. It indicated that direct selection for these traits might be effective since the heritability is most likely due to additive gene effect. Significant positive correction along with direct effects was recorded for harvest index (%), per plant biological yield, angle of flag leaf, and productive no. of tillers/ plant on pooled analysis. These discussed traits might be taken in the expansion of selection criteria for genetic enhancement of per plant grain yield in advance breeding lines of rice under different planting spacing conditions.

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Conflict of interest
The authors declare that they have no conflict of interest.

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