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Interrelationship of Yield and Quality Attributing Traits in JNPT Lines of Rice

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Abstract

In present study, one hundred eighty five JNPT (Jawahar New Plant Type) lines including five checks were evaluated for twenty eight morphological and quality traits planted in Randomized Complete Block Design with three replications. The experiment was conducted during *kharif* seasons of 2014 and 2015 at Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur (M.P.), India. Observations were recorded on the basis of middle five random competitive plants selected from each line in every replication for yield and quality traits. Considerable genetic variability was exhibited by all the yield and quality traits under study. It was observed that for selecting the high yielding lines in the rice the characters viz., spikelet density, fertile spikelets panicle^{-1}, number of spikelets per panicle, panicle weight plant^{-1} and biological yield plant^{-1} might be considered. On the basis of high PC score in principal component analysis 10 most prominent JNPT lines JNPT 813, JNPT 811, JNPT 845, JNPT 770, JNPT 779, JNPT 777, JNPT 778, JNPT 749, JNPT 781 and JNPT(S) 10H were identified. Thus, these JNPT lines will be utilized as inbred for production of hybrid rice, with higher yield and better quality. However, after evaluation under different agro-ecological rice growing situations, these lines might be released as high yielding variety with better quality.

Keywords: Rice, JNPT lines, PC score, PCA, variability

1. Introduction

Rice (*Oryza sativa* L.) is the basic food crop of Asia, providing over 30% of the calories consumed in the region (Narciso and Hossain, 2002). Rice production in Asia has increased by 2.6 times since 1961, primarily as a result of the "Green Revolution", which dramatically increased the rice productivity in the high-input irrigated systems (Khush, 1999). Enhancing crop yield is one of the top most priorities in crop breeding programmes. Results have indicated that an effective way to develop super rice lies first in developing the new plant type and strong vigour by crossing *Indica* with *Japonica* subspecies, and then consolidating the two advantages by optimizing the combination of desirable traits via multiple crossing and backcrossing (Cheng et al., 2001). In the late 1980s, to increase yield potential in *Indica* inbred varieties under a tropical environment, a breeding programme to develop new plant type (NPT) rice was launched at IRRI. The NPTlines had several traits from tropical *Japonica*: low tillering habit, few unproductive tillers, large panicles, thick culm, lodgingresistance, and large and dark green flag leaves (Khush, 1995). Especially, the NPT lines had elite characteristics such as larger flag leaves, higher spikelet number, and heavier grain weight than IR64. Thus, these lines were thought to be useful materials to improve the yield potential of IRRI-bred varieties, including IR64. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (India) has made JNPT (Jawahar New Plant Type) lines through tropical *Japonica*×*Indica* hybridization using wide compatibility gene source. The *Indica* lines used to develop the JNPT lines were very popular for high yield and quality aspects. Derived lines combine strong culm, short stature, dark green erect leaves, long panicles, high grain numbers with improved quality.

Magnitude of genetic variability present in the plant population decides the efficiency of selection as well as development of an effective plant breeding strategy. Correlations help the breeder to understand the mutual component characters on which selection can be based for genetic improvement (Chakravorty et al., 2013). Information on association of the characters, direct and indirect effects contributed by each trait towards yield will be an added advantage in aiding the selection process and helps the breeder to design his selection strategies for improving the grain yield (Ravindrababu et al., 2012). Principal Component Analysis (PCA) is one of the tools available for summarizing and describing the inherent genetic variation in crop genotypes. This technique helps in identification of traits that help in distinguishing selected genotypes based on similarities in one or more traits and classify the genotypes into separate groups (Ariyo, 1987 and Nair et al., 1998). The PCA has been used by Nassir, 2002 and Chakravorty et al., 2013 in rice for partitioning observed variation and studying inter relationships among different traits. PCA helps to identify the traits with high variability, correlations reveal the strength of relationship between different traits with yield. Thus, to identify the yield and quality traits of utmost importance the present investigation was conducted in rice by studying genetic parameters and interrelationship of yield and quality traits in JNPT lines.

2. Materials and Methods

The experimental material consists of 180 JNPT lines derived from *Indica*×*Japonica* subspecies crosses (F_{14}- F_{15} generation's) developed by JNKVV, Jabalpur with 5 checks were grown during *Kharif* seasons of 2014 and 2015 at Seed Breeding Farm, JNKVV, Jabalpur (M.P.), India. These lines were planted in Randomized Complete Block Design with three replications. Twenty one days old seedlings were transplanted in the experimental site with spacing of 20 cm between plant to plant and 30 cm between the rows, keeping single seedling per hill. Gap filling was done within a week in order to maintain uniform plant population. Fertilizer dose of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O was applied. Observations were recorded on the basis of middle five random competitive plants selected from each line in every replication for yield and quality traits. The data for each trait was statistically analyzed using analysis of variance recommended for randomized complete block design. The mean values were used to obtain analysis of variance as per methodology advocated by Panse and Sukhatme (1967). PCV and GCV were calculated by the formula given by Burton (1952), heritability in broad sense by Burton (1952) and Burton and De Vane (1953) and genetic advance i.e. the expected genetic gain was calculated by using the procedure given by Johnson et al., 1955. Correlation coefficient and path coefficient analysis was worked out as method suggested by Al-Jibouri et al., 1958 and Dewey and Lu (1959) respectively. Genetic and phenotypic correlations among the traits were determined by Singh and Chaudhary (2005) method. The simplified procedure of (Juliano, 1971) is used for the amylose contentanalysis. PCA analysis was done using the methodology given by (Massy, 1965; Jolliffe, 1986).

3. Results and Discussion

3.1. Genetic parameter

The mean value of different characters were tested for homogeneity by Bartlett's test and found non-significant. Thus, the pooled result of two years was obtained by computing the mean value of different traits from two years. All yield attributing traits showed the considerable amount of variability. The total number of spikelets panicle^{-1} (34420.0178) showed maximum variability, whereas, stem thickness (0.0674) exhibited minimum variability, which was in agreement with the findings of Kumar et al. (2015). Highest genotypic and phenotypic coefficient of variation observed by spikelet density (34.77 and 34.91) while, low GCV and PCV by hulling percentage (4.53 and 4.59). High heritability coupled with high genetic advance expressed by spikelet density followed by fertile spikelets panicle^{-1}, number of spikelets panicle^{-1}, number of productive tillers plant^{-1}, panicle weight per plant, amylose content, number of tillers plant^{-1}, grain yield plant^{-1}, biological yield plant^{-1}, 1000-grain weight, flag leaf width, harvest index, flag leaf length, panicle index, stem length, grain length, plant height, grain breadth, decorticated grain l/b ratio, panicle length and decorticated grain length (Table 1). This was in consonance with the findings of Bekele et al. (2013), Rajput et al. (2014); Shrivastava et al. (2014) and Dongre et al. (2014).

3.2. Character association

Grain yield plant^{-1} revealed significant and positive association with panicle weight plant^{-1}, biological yield per plant, number of productive tillers plant^{-1}, harvest index, number of tillers plant^{-1}, fertile spikelets per panicle, spikelet density, number of spikelets panicle^{-1}, flag leaf length, panicle index, days to 50% flowering, grain breadth, days to maturity, spikelet fertility, hulling percentage and amylose content in continues two years and pooled result of two years. Similar findings were reported by Sohgaura et al. (2014), Singh et al. (2014), Dongre et al. (2014); Shrivastava et al. (2014). Considering the results from correlation and path coefficient analysis, it is concluded that for selecting the high yielding lines in rice the characters viz., panicle weight plant^{-1}, panicle index, biological yield per plant, harvest index, number of productive tiller plant^{-1}, spikelet density, panicle length, spikelet fertility and 1000-grain weight might be considered (Table 2(a), 2(b), 3(a) & 3(b)).

3.3. Principal component analysis

To find out independent impact of all the characters under study principal component analysis was conducted. In JNPT lines, the first principal component accounted for maximum proportion of total variability in the set of all variables and remaining components accounted for progressively lesser and lesser amount of variation. Out of 28 principal components (PCs) only eight PCs exhibited more than 1.00 Eigen value and about 75.61% variability among the traits studied (Table 4). So, these eight PC's were given due importance for further explanation. Highest variability (20.69%) was exhibited by PC1 however, PC2, PC3, PC4, PC5, PC6, PC7 and PC8 revealed 14.20%, 9.89%, 8.90%, 6.45%, 5.62%, 5.30% and 4.54% variability, respectively among the lines for the traits under

Table 1: Genetic parameters of yield and quality traits of JNPT lines of rice

Sl. No.	Traits	Mean	Range		GCV (%)	PCV (%)	h^2 (Broad Sense %)	Genetic Advance	Gen. Adv as % of mean
			Mini.	Maxi.					
1.	DFF	103.60	84.11	131.91	8.81	8.82	99.7	18.788	18.136
2.	DTM	129.91	108.72	157.34	7.03	7.04	99.6	18.788	14.462
3.	FLL	40.30	20.63	60.36	19.59	19.645	99.4	16.22	40.244
4.	FLW	1.99	0.87	2.98	19.74	19.81	99.2	0.807	40.512
5.	ST	1.94	1.57	2.37	7.69	7.82	96.7	0.302	15.575
6.	SL	94.04	62.17	141.00	17.07	18.87	90.46	32.996	35.089
7.	PH	121.96	87.64	179.79	14.76	14.98	98.53	37.05	30.381
8.	PL	27.92	19.77	40.58	13.23	13.47	96.5	7.476	26.778
9.	TPP	6.99	3.50	15.44	27.54	27.66	99.1	3.946	56.493
10.	PTPP	6.46	3.15	13.52	28.48	28.7	98.5	3.764	58.232
11.	BYPP	74.13	24.82	120.36	23.22	23.97	96.87	35.39	47.73
12.	PWPP	29.67	12.05	60.57	28.56	29.71	96.12	17.44	58.80
13.	FSPP	276.36	104.78	567.99	32.41	32.99	98.24	186.22	67.38
14.	TSPP	334.62	138.68	708.59	32.01	32.82	97.53	220.65	65.94
15.	SF	82.91	56.45	94.85	9.84	9.86	99.8	16.79	20.26
16.	SD	12.20	5.45	25.69	34.77	34.91	99.2	8.70	71.34
17.	TGW	24.97	11.59	36.62	20.86	20.87	99.9	10.73	42.96
18.	HI	32.88	17.61	49.26	20.32	20.50	98.3	13.64	41.49
19.	PI	82.67	44.35	132.42	18.29	18.46	98.2	30.87	37.34
20.	GL	8.80	5.46	12.51	15.03	15.06	99.5	2.72	30.88
21.	GB	2.65	2.18	4.05	12.82	12.84	99.7	0.70	26.37
22.	HP	77.80	60.21	85.57	4.53	4.59	98.69	7.26	9.33
23.	MP	66.83	30.88	77.54	9.12	9.39	97.12	12.54	18.77
24.	DGL	5.45	4.06	7.57	11.08	11.11	99.6	1.24	22.79
25.	DGB	2.22	1.83	3.05	7.78	7.85	98.3	0.35	15.89
26.	DLBR	2.47	1.66	3.71	13.02	13.10	98.9	0.66	26.68
27.	AP	18.72	11.33	31.35	27.29	27.69	98.5	10.52	56.19
28.	GYPP	23.96	11.92	45.57	26.22	26.58	98.64	12.91	53.86

study. Rotated component matrix revealed that each principal component separately loaded with various yield and quality attributing traits under study (Table 5). The PC1 was more related to the yield attributing traits viz., spikelet density, fertile spikelets per panicle and number of spikelets per panicle. PC2 exhibited positive effect for grain yield per plant, panicle weight per plant and biological yield plant^{-1}, which were more loaded with yield contributing traits. Thus, PC1 and PC2 allowed for simultaneous selection of yield related traits and it can be regarded as yield factor. The 5th principal component was more linked to quality attributing traits i.e., decorticated grain length and decorticated grain l/b ratio. Similarly, eighth PC also more dominated with quality traits such as hulling percentage and milling percentage. Remaining principal components (PC3, PC4, PC6 and PC7) more loaded with physiological traits (Table 6). This result was in agreement with Yang et al. (2009), Ashfaq et al. (2012) and Kumar et al. (2014). On the basis of PCA study, it was cleared that the JNPT 810, JNPT 754, JNPT 800, JNPT 752, JNPT 811, JNPT 751, JNPT 748, JNPT 820, JNPT 822 and JNPT 830 were the selected 10 promising lines for both yield and quality attributes. Because, these genotypes performing their presence with high PC score in both yield (PC1or PC2) as well as quality (PC5 or PC8) related PC's. Therefore, selection of genotype in these PCs will be more accurate in comparison to other PCs. (Table 7).

Table 2(a): Phenotypic correlation among yield and quality traits for JNPT lines of rice

Traits	DFF	DTM	FLL	FLW	ST	SL	PH	PL	TPP	PTPP	BYPP	PWPP	FSPP	TSPP
DFF	1.0000	0.9770**	0.2282**	0.0832*	0.2657**	-0.1276**	-0.1497**	-0.1715**	0.0174	0.0308	0.1486**	0.1909**	0.3146**	0.3688**
DTM		1.0000	0.2051**	0.069	0.2595**	-0.1166**	-0.1368**	-0.1570**	0.0037	0.0124	0.1080*	0.1644**	0.3131**	0.3616**
FLL			1.0000	0.1930**	0.2682**	0.1194**	0.1392**	0.1563**	-0.1569**	-0.1390**	0.2358**	0.2646**	0.3448**	0.4228**
FLW				1.0000	0.3681**	0.063	0.0789	0.1085*	-0.3906**	-0.3985**	0.1398**	0.0924*	0.2197**	0.2546**
ST					1.0000	0.1262**	0.1464**	0.1618**	-0.2851**	-0.2879**	0.1714**	0.1425**	0.1485**	0.2441**
SL						1.0000	0.9821**	0.4289**	-0.2413**	-0.2336**	0.2513**	-0.045	0.0919*	0.1185**
PH							1.0000	0.5915**	-0.2853**	-0.2772**	0.2355**	-0.0494	0.0646	0.1104**
PL								1.0000	-0.3354**	-0.3295**	0.0535	-0.0443	-0.0839*	0.0223
TPP									1.0000	0.9809**	0.4023**	0.3553**	0.0032	-0.0739
PTPP										1.0000	0.4187**	0.3781**	0.0086	-0.0697
BYPP											1.0000	0.7462**	0.2809**	0.3044**
PWPP												1.0000	0.3147**	0.3193**
FSPP													1.0000	0.9480**
TSPP														1.0000
SF														
SD														
TGW														
HI														
PI														
GL														
GB														
HP														
MP														
DGL														
DGB														
DLBR														
AP														
GYPP	0.1792**	0.1525**	0.2965**	0.0316	0.0096	-0.0592	-0.0706	-0.085**	0.4566**	0.4889**	0.6563**	0.7876**	0.4344**	0.3977**

*,**,***: Significant at (p=0.01) and (p=0.05) (p=0.001) level respectively

Table 2(b): Phenotypic correlation among yield and quality traits for JNPT lines of rice

Traits	SF	SD	TGW	HI	PI	GL	GB	HP	MP	DGL	DGB	DLBR	AP
DFF	-0.1533**	0.4191**	-0.3430**	0.0334	-0.0295	-0.4046**	-0.1073*	0.2204**	0.1677**	-0.2213**	0.0455	-0.2188**	0.0910*
DTM	-0.1287**	0.4072**	-0.3594**	0.0486	-0.0281	-0.3928**	-0.1188**	0.2147**	0.1731**	-0.1897**	0.0202	-0.1745**	0.0678
FLL	-0.2638**	0.3428**	-0.2572**	0.1066*	-0.0151	-0.1064*	0.0562	-0.0476	0.0168	-0.0549	-0.0757	-0.0163	-0.1378**
FLW	-0.1319**	0.1960**	0.0885*	-0.1696**	-0.1617**	-0.0284	0.2263**	0.0982*	-0.0064	-0.0188	0.0992*	-0.0623	-0.0746
ST	-0.3185**	0.1629**	-0.0086	-0.2110**	-0.2281**	-0.1739**	0.1273**	-0.0001	-0.0195	-0.0234	0.1484**	-0.0983*	-0.0939*
SL	-0.0749	-0.0275	0.0276	-0.3340**	0.0569	0.2505**	0.0339	-0.0994*	0.0065	0.3189**	-0.0673	0.3096**	-0.027
PH	-0.1330**	-0.0990*	0.0823	-0.3276**	-0.066	0.3146**	0.0599	-0.1438**	-0.0246	0.3807**	-0.0588	0.3575**	-0.0256
PL	-0.3170**	-0.3569**	0.2763**	-0.1411**	-0.0731	0.4359**	0.1420**	-0.2638**	-0.1457**	0.4603**	0.0057	0.3888**	-0.007
TPP	0.2342**	0.0695	-0.1835**	0.0847*	0.1501**	-0.2007**	-0.0870*	0.0483	0.0045	-0.3279**	-0.0476	-0.2504**	0.2453**
PTPP	0.2336**	0.0694	-0.1770**	0.1092*	0.1638**	-0.1945**	-0.0934*	0.035	-0.0025	-0.3176**	-0.038	-0.2473**	0.2361**
BYPP	-0.077	0.2755**	0.0706	-0.3423**	-0.2286**	-0.1643**	0.0924*	0.0165	-0.0287	-0.1492**	0.0129	-0.1265**	0.0345
PWPP	-0.0073	0.3079**	-0.0831	0.0814	-0.4259**	-0.2705**	0.1823**	0.0518	0.0101	-0.2556**	-0.0239	-0.1993**	-0.0473
FSPP	0.1884**	0.9154**	-0.5334**	0.1853**	0.1031*	-0.3454**	-0.0369	0.1450**	0.0850*	-0.2401**	-0.1919**	-0.0977*	-0.0422
TSPP	-0.1211**	0.9178**	-0.4885**	0.1252**	0.04	-0.3258**	-0.0167	0.0996*	0.0766	-0.1727**	-0.1553**	-0.063	-0.0348
SF	1.0000	0.018	-0.1456**	0.1943**	0.1944**	-0.0439	-0.0568	0.1111**	-0.0235	-0.1986**	-0.1300**	-0.0864*	-0.0289
SD		1.0000	-0.5928**	0.1480**	0.0622	-0.4832**	-0.0918*	0.1994**	0.1294**	-0.3313**	-0.1677**	-0.1908**	-0.0302
TGW			1.0000	-0.0865*	-0.083	0.4371**	0.2630***	-0.1165**	-0.0812	0.2626***	0.2049***	0.1224**	0.0027
HI				1.0000	0.5483**	-0.0551	0.0934*	0.1642**	0.1350**	-0.1969**	-0.1315**	-0.0942*	0.1157**
PI					1.0000	0.1076*	-0.0569	0.1104**	0.0515	-0.0927*	-0.1211**	-0.0091	0.2371**
GL						1.0000	0.0185	-0.2752**	-0.1480**	0.4940***	-0.017	0.4271**	-0.011
GB							1.0000	0.0219	-0.0972*	-0.0517	0.2846**	-0.1931**	-0.0067
HP								1.0000	0.5248**	-0.3582**	-0.1253**	-0.2304**	0.0762
MP									1.0000	-0.1311**	-0.2338**	0.0015	0.1067*
DGL										1.0000	0.0648	0.8128**	0.0979*
DGB											1.0000	-0.5193**	-0.0295
DLBR												1.0000	0.1022*
AP													1.0000
GYPP	0.1218**	0.3953**	-0.1391**	0.4575**	0.2036**	-0.2149**	0.1884**	0.1322**	0.0459**	-0.3184**	-0.108**	-0.2027**	0.1048**

*,**,***: Significant at (p=0.01) and (p=0.05) (p=0.001) level respectively

Table 3(a): Genotypic path among yield and quality traits for JNPT lines of rice

Traits	DFF	DTM	FLL	FLW	ST	SL	PH	PL	TPP	PTPP	BYPP	PWPP	FSPP	TSPP
DFF	0.0218	0.0214	0.0050	0.0018	0.0059	-0.0028	-0.0033	-0.0038	0.0004	0.0007	0.0032	0.0042	0.0069	0.0081
DTM	-0.0153	-0.0156	-0.0032	-0.0011	-0.0041	0.0018	0.0021	0.0025	-0.0001	-0.0002	-0.0017	-0.0026	-0.0049	-0.0056
FLL	0.0023	0.0021	0.0102	0.0020	0.0028	0.0012	0.0014	0.0016	-0.0016	-0.0014	0.0024	0.0027	0.0035	0.0043
FLW	0.0030	0.0025	0.0070	0.0363	0.0137	0.0023	0.0029	0.0040	-0.0143	-0.0146	0.0051	0.0034	0.0080	0.0093
ST	0.0005	0.0005	0.0005	0.0007	0.0018	0.0002	0.0003	0.0003	-0.0005	-0.0005	0.0003	0.0003	0.0003	0.0004
SL	-0.0269	-0.0247	0.0253	0.0133	0.0271	0.2105	0.2069	0.0938	-0.0512	-0.0497	0.0531	-0.0094	0.0194	0.0250
PH	0.0337	0.0309	-0.0315	-0.0178	-0.0335	-0.2209	-0.2247	-0.1354	0.0645	0.0629	-0.0531	0.0111	-0.0145	-0.0248
PL	-0.0089	-0.0081	0.0080	0.0056	0.0085	0.0225	0.0305	0.0506	-0.0173	-0.0170	0.0028	-0.0023	-0.0043	0.0012
TPP	0.0011	0.0002	-0.0104	-0.0258	-0.0190	-0.0159	-0.0188	-0.0225	0.0656	0.0649	0.0266	0.0234	0.0002	-0.0049
PTPP	-0.0013	-0.0005	0.0057	0.0164	0.0120	0.0096	0.0114	0.0137	-0.0404	-0.0408	-0.0173	-0.0156	-0.0004	0.0029
BYPP	0.0455	0.0330	0.0723	0.0430	0.0532	0.0770	0.0721	0.0167	0.1235	0.1291	0.3051	0.2283	0.0859	0.0931
PWPP	0.1323	0.1141	0.1836	0.0640	0.1005	-0.0311	-0.0341	-0.0314	0.2469	0.2636	0.5174	0.6916	0.2178	0.2210
FSPP	-0.0169	-0.0168	-0.0185	-0.0118	-0.0081	-0.0049	-0.0035	0.0046	-0.0002	-0.0005	-0.0151	-0.0169	-0.0536	-0.0508
TSPP	0.0133	0.0130	0.0153	0.0092	0.0089	0.0043	0.0040	0.0008	-0.0027	-0.0025	0.0110	0.0115	0.0341	0.0360
SF	-0.0062	-0.0052	-0.0106	-0.0053	-0.0130	-0.0030	-0.0053	-0.0130	0.0094	0.0094	-0.0031	-0.0003	0.0075	-0.0049
SD	0.0217	0.0211	0.0178	0.0102	0.0085	-0.0016	-0.0051	-0.0180	0.0036	0.0036	0.0143	0.0159	0.0473	0.0474
TGW	-0.0068	-0.0071	-0.0051	0.0018	-0.0002	0.0005	0.0016	0.0056	-0.0036	-0.0035	-0.0014	-0.0016	-0.0105	-0.0097
HI	0.0093	0.0136	0.0297	-0.0476	-0.0598	-0.0933	-0.0914	-0.0402	0.0237	0.0304	-0.0944	0.0228	0.0517	0.0349
PI	-0.0125	-0.0120	-0.0064	-0.0681	-0.0979	-0.0237	-0.0276	-0.0313	0.0632	0.0691	-0.0963	-0.1782	0.0434	0.0168
GL	0.0016	0.0016	0.0004	0.0001	0.0007	-0.0010	-0.0013	-0.0018	0.0008	0.0008	0.0007	0.0011	0.0014	0.0013
GB	-0.0033	-0.0036	0.0017	0.0070	0.0040	0.0010	0.0018	0.0044	-0.0027	-0.0029	0.0028	0.0056	-0.0011	-0.0005
HP	-0.0008	-0.0008	0.0002	-0.0004	0.0000	0.0004	0.0005	0.0010	-0.0002	-0.0001	-0.0001	-0.0002	-0.0005	-0.0004
MP	-0.0019	-0.0020	-0.0002	0.0001	0.0002	-0.0001	0.0003	0.0017	-0.0001	0.0000	0.0003	-0.0001	-0.0010	-0.0009
DGL	-0.0054	-0.0046	-0.0013	-0.0005	-0.0006	0.0077	0.0092	0.0113	-0.0080	-0.0077	-0.0036	-0.0062	-0.0058	-0.0042
DGB	-0.0010	-0.0004	0.0016	-0.0021	-0.0031	0.0014	0.0013	-0.0001	0.0010	0.0008	-0.0003	0.0005	0.0041	0.0033
DLBR	0.0012	0.0010	0.0001	0.0003	0.0005	-0.0017	-0.0020	-0.0022	0.0014	0.0014	0.0007	0.0011	0.0005	0.0003
AP	-0.0006	-0.0005	0.0009	0.0005	0.0006	0.0002	0.0002	0.0001	-0.0016	-0.0016	-0.0002	0.0003	0.0003	0.0002

R square=0.9850

Residual effect = 0.1224

Table 3(b): Genotypic path among yield and quality traits for JNPT lines of rice

Traits	SF	SD	TGW	HI	PI	GL	GB	HP	MP	DGL	DGB	DLBR	AP	Correlation with GYPP
DFF	-0.0034	0.0092	-0.0075	0.0007	-0.0007	-0.0089	-0.0023	0.0048	0.0037	-0.0048	0.0010	-0.0048	0.0020	0.1798
DTM	0.0020	-0.0064	0.0056	-0.0008	0.0004	0.0061	0.0019	-0.0033	-0.0027	0.0030	-0.0003	0.0027	-0.0011	0.1531
FLL	-0.0027	0.0035	-0.0026	0.0011	-0.0002	-0.0011	0.0006	-0.0005	0.0002	-0.0006	-0.0008	-0.0002	-0.0014	0.2981
FLW	-0.0048	0.0072	0.0032	-0.0062	-0.0059	-0.0010	0.0083	0.0036	-0.0002	-0.0007	0.0036	-0.0023	-0.0027	0.0317
ST	-0.0006	0.0003	0.0000	-0.0004	-0.0004	-0.0003	0.0002	0.0000	0.0000	0.0000	0.0003	-0.0002	-0.0002	0.0097
SL	-0.0157	-0.0065	0.0058	-0.0710	-0.0120	0.0530	0.0072	-0.0210	0.0014	0.0674	-0.0142	0.0656	-0.0057	-0.0593
PH	0.0299	0.0223	-0.0185	0.0743	0.0149	-0.0709	-0.0135	0.0324	0.0055	-0.0858	0.0133	-0.0808	0.0057	-0.0707
PL	-0.0164	-0.0177	0.0142	-0.0073	-0.0038	0.0224	0.0073	-0.0136	-0.0075	0.0237	0.0002	0.0201	-0.0004	-0.087
TPP	0.0155	0.0046	-0.0121	0.0056	0.0100	-0.0133	-0.0058	0.0032	0.0003	-0.0216	-0.0032	-0.0166	0.0162	0.4597
PTPP	-0.0096	-0.0028	0.0073	-0.0045	-0.0068	0.0080	0.0039	-0.0014	0.0001	0.0131	0.0016	0.0102	-0.0097	0.4935
BYPP	-0.0236	0.0846	-0.0216	-0.1041	-0.0705	-0.0503	0.0283	0.0051	-0.0088	-0.0457	0.0045	-0.0392	0.0105	0.6593
PWPP	-0.0051	0.2141	-0.0576	0.0570	-0.2959	-0.1876	0.1265	0.0360	0.0071	-0.1774	-0.0165	-0.1389	-0.0327	0.7904
FSPP	-0.0101	-0.0493	0.0286	-0.0100	-0.0056	0.0186	0.0020	-0.0078	-0.0046	0.0129	0.0104	0.0053	0.0023	0.4357
TSPP	-0.0044	0.0332	-0.0176	0.0045	0.0014	-0.0118	-0.0006	0.0036	0.0028	-0.0062	-0.0056	-0.0023	-0.0013	0.3989
SF	0.0401	0.0007	-0.0058	0.0079	0.0079	-0.0018	-0.0023	0.0045	-0.0009	-0.0080	-0.0053	-0.0035	-0.0012	0.1226
SD	0.0010	0.0514	-0.0306	0.0077	0.0032	-0.0250	-0.0047	0.0103	0.0067	-0.0171	-0.0087	-0.0099	-0.0015	0.3978
TGW	-0.0029	-0.0118	0.0198	-0.0017	-0.0017	0.0087	0.0052	-0.0023	-0.0016	0.0052	0.0041	0.0024	0.0001	-0.1396
HI	0.0544	0.0413	-0.0241	0.2767	0.1509	-0.0153	0.0259	0.0459	0.0376	-0.0550	-0.0377	-0.0260	0.0323	0.4553
PI	0.0821	0.0260	-0.0349	0.2271	0.4164	0.0456	-0.0244	0.0464	0.0214	-0.0388	-0.0516	-0.0034	0.0997	0.1973
GL	0.0002	0.0020	-0.0018	0.0002	-0.0004	-0.0041	-0.0001	0.0011	0.0006	-0.0020	0.0001	-0.0017	0.0000	-0.2155
GB	-0.0017	-0.0028	0.0081	0.0029	-0.0018	0.0006	0.0305	0.0007	-0.0030	-0.0016	0.0088	-0.0059	-0.0002	0.1888
HP	-0.0004	-0.0007	0.0004	-0.0006	-0.0004	0.0010	-0.0001	-0.0037	-0.0019	0.0013	0.0005	0.0009	-0.0003	0.1326
MP	0.0003	-0.0015	0.0009	-0.0015	-0.0006	0.0017	0.0011	-0.0059	-0.0112	0.0015	0.0027	0.0000	-0.0012	0.0459
DGL	-0.0048	-0.0080	0.0063	-0.0048	-0.0022	0.0120	-0.0013	-0.0087	-0.0032	0.0241	0.0016	0.0197	0.0024	-0.3197
DGB	0.0028	0.0036	-0.0044	0.0029	0.0026	0.0004	-0.0061	0.0027	0.0050	-0.0014	-0.0211	0.0109	0.0006	-0.1094
DLBR	0.0005	0.0011	-0.0007	0.0005	0.0000	-0.0024	0.0011	0.0013	0.0000	-0.0045	0.0028	-0.0055	-0.0006	-0.2042
AP	0.0002	0.0002	0.0000	-0.0008	-0.0016	0.0001	0.0000	-0.0005	-0.0007	-0.0007	0.0002	-0.0007	-0.0067	0.1051

R square=0.9850

Residual effect = 0.1224

Table 4: Eigen value and percentage of variation for corresponding 28 yield and quality traits in JNPT lines of rice

Traits	Principal component (PC)	Eigen value	Percentage of total variation	Cumulative percentage
DFF	PC1	5.793	20.690	20.690
DTM	PC2	3.977	14.205	34.895
FLL	PC3	2.770	9.892	44.787
FLW	PC4	2.494	8.908	53.695
ST	PC5	1.806	6.451	60.145
SL	PC6	1.575	5.624	65.770
PH	PC7	1.485	5.303	71.073
PL	PC8	1.272	4.542	75.615
TPP	PC9	0.999	3.567	79.182
PTPP	PC10	0.875	3.126	82.309
BYPP	PC11	0.734	2.621	84.930
PWPP	PC12	0.661	2.362	87.292
FSPP	PC13	0.576	2.058	89.350
TSPP	PC14	0.549	1.960	91.310
SF	PC15	0.515	1.840	93.150
SD	PC16	0.454	1.620	94.770
TGW	PC17	0.420	1.501	96.272
HI	PC18	0.380	1.359	97.630
PI	PC19	0.341	1.218	98.848
GL	PC20	0.256	0.915	99.764
GB	PC21	0.019	0.067	99.831
HP	PC22	0.015	0.052	99.883
MP	PC23	0.012	0.042	99.925
DGL	PC24	0.008	0.028	99.952
DGB	PC25	0.006	0.021	99.974
DLBR	PC26	0.004	0.015	99.989
AP	PC27	0.003	0.011	100.000

Table 5: Interpretation of rotated component matrix for the traits having high values (>0.5) in each PCs

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Traits	FSPP	BYPP	FLW	PL	DGL	DFF	HI	HP
	TSPP	PWPP	-	PH	DGLBR	DTM	PI	MP
	SD	GYPP	-	SL	-	-	-	-

Table 6: Principal components for 28 yield and quality traits in JNPT lines of rice

Rotated component matrix[a]								
Traits	Component							
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
DFF	0.351	0.032	-0.005	-0.125	-0.120	0.826	-0.015	0.159
DTM	0.358	-0.003	-0.008	-0.121	-0.084	0.815	-0.013	0.160
FLL	0.370	0.302	0.382	0.044	0.131	0.212	0.103	-0.141

Continue...

Rotated Component Matrixa								
Traits	Component							
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
FLW	0.112	0.103	0.655	0.062	-0.147	0.008	-0.117	0.101
ST	0.102	0.110	0.497	0.121	-0.165	0.379	-0.226	-0.031
SL	0.083	-0.007	0.069	0.938	0.077	-0.077	-0.114	0.027
PH	0.021	0.012	0.133	0.950	0.128	-0.054	-0.080	-0.031
PL	-0.258	0.086	0.349	0.553	0.286	0.072	0.105	-0.265
TPP	0.006	0.470	-0.789	-0.157	-0.162	-0.014	0.051	0.009
PTPP	0.008	0.491	-0.787	-0.154	-0.155	-0.005	0.071	-0.007
BYPP	0.163	0.806	-0.133	0.295	-0.110	0.096	-0.284	0.001
PWPP	0.164	0.909	0.029	-0.113	-0.032	0.052	-0.186	0.026
FSPP	0.903	0.214	0.140	0.081	-0.008	-0.007	0.136	0.051
TSPP	0.846	0.241	0.253	0.109	0.043	0.157	0.104	-0.009
SF	0.207	-0.090	-0.360	-0.081	-0.142	-0.517	0.110	0.146
SD	0.905	0.185	0.082	-0.084	-0.057	0.126	0.037	0.101
TGW	-0.752	0.087	0.264	0.065	-0.003	-0.147	0.051	-0.033
HI	0.126	0.093	0.030	-0.377	0.063	-0.090	0.805	0.099
PI	0.122	-0.216	-0.241	0.065	-0.054	-0.062	0.815	0.048
GL	-0.452	-0.110	0.094	0.315	0.338	-0.238	0.195	-0.242
GB	-0.245	0.308	0.415	0.086	-0.407	-0.118	0.236	-0.038
HP	0.084	0.021	0.036	-0.075	-0.168	0.051	0.093	0.838
MP	0.012	0.008	0.013	-0.001	0.160	0.129	0.054	0.819
DGL	-0.316	-0.182	0.124	0.356	0.574	0.091	0.000	-0.338
DGB	-0.267	-0.060	0.131	0.044	-0.690	0.189	-0.029	-0.340
DLBR	-0.124	-0.113	0.034	0.279	0.880	-0.037	0.017	-0.097
AP	-0.167	0.064	-0.332	0.152	0.047	0.339	0.383	0.123
GYPP	0.274	0.845	-0.090	-0.056	-0.066	0.002	0.353	0.063

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization

Table 7: Selected JNPT lines of rice on the basis of high PC score for pooled data of two years

PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
JNPT 814	JNPT 35-01	JNPT 753	JNPT (S) 10-1 C	JNPT 769	JNPT 780	JNPT 759	JNPT 754
JNPT 813	JNPT 37-01 A	JNPT 806	JNPT 771	JNPT (S) 10-1 C	JNPT 781	PUSA BASMATI 1	JNPT 792
JNPT 816	JNPT-24	JNPT 765	JNPT (S) 10 E	Sahbhagi	JNPT-47	JNPT 851	JNPT 776
JNPT 810	JNPT 32-01	JNPT 838	JNPT (S) 10-1 B	JNPT 849	JNPT 39-01	JNPT 762	JNPT 749
JNPT 779	JNPT 25-01	JNPT 63-01 A	JNPT (S) 10 F	JNPT (S) 10 G	JNPT 779	JNPT 831	JNPT 755
JNPT 778	JNPT-49	JNPT 799	JNPT (S) 10 G	JNPT 800	JNPT 749	JNPT 787	JNPT 800
JNPT 777	JNPT-25	JNPT 35-01	JNPT (S) 10	JNPT (S) 7-1 B	JNPT 816	IR64	JNPT-23
JNPT 752	JNPT 760	JNPT 773	JNPT 772	JNPT 770	JNPT 24-01	Sahbhagi	JNPT 822
JNPT 811	JNPT (S) 6-6 B	JNPT 851	JNPT (S) 10-1 A	JNPT (S) 10 H	JNPT 748	JNPT 850	JNPT 820
JNPT 751	JNPT 761	JNPT 39-01	JNPT (S) 10-1-1 B	JNPT 38-01	JNPT 57-01	JNPT 807	JNPT 753
JNPT 846	JNPT-01	JNPT (S) 10-1-1 A	JNPT (S) 10 B	JNPT 754	JNPT 783	JNPT 838	JNPT 751

Continue...

PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
JNPT 819	JNPT 27-01	JNPT 802	JNPT (S) 10 H	JNPT 841	JNPT 38-01	JNPT 80-01	JNPT 811
JNPT 750	JNPT-17	JNPT 782	JNPT (S) 10 D	JNPT 834	JNPT 40-01	JNPT 828	JNPT 810
JNPT 749	JNPT 57-01	JNPT 25-01	JNPT-41	JNPT (S) 7-1 C	JNPT 764	JNPT 776	JNPT 752
JNPT 796	JNPT 758	JNPT 758	JNPT 788	JRH-8	HMT	JNPT 767	JNPT (S) 8-1 A
JNPT (S) 8-1 B	JNPT 754	JNPT (S)23-1 A	JNPT-47	JNPT 840	JNPT 63-01 A	JNPT 821	JNPT 63-01 B
JNPT 748	JNPT 844	JNPT 808	JNPT-49	JNPT 79-01	JNPT13-01	JNPT (S) 35-2 A	JNPT 850
JNPT 824	JNPT-35-1	JNPT 756	JNPT (S)4-1	JNPT (S) 7-1 A	JNPT (S) 10-1 C	JNPT 843	JNPT 788
JNPT 800	JNPT 845	JNPT 794	JNPT 770	JNPT 781	JNPT 750	JNPT 765	JNPT 65-01
JNPT 780	JNPT 810	JNPT 79-01	JNPT (S) 10 A	JNPT (S) 35-2 A	JNPT 41-01	JNPT 819	JNPT 23-01
JNPT 820	JNPT 38-01	JNPT 760	JNPT 845	JNPT 774	JNPT 752	JNPT (S)23-1	JNPT 748
JNPT 843		JNPT 791	JNPT 848	JNPT 830	JNPT 777	JNPT 847	JNPT 757
JNPT 822		JNPT 762	JNPT 791	JNPT (S) 10-1-1 A	JNPT 23-01	JNPT 761	JNPT 825
JNPT 830			JNPT (S) 10 C	JNPT 57-01	JNPT 771	JNPT 25-01	JNPT 71-01

4. Conclusion

Selecting the high yielding lines in rice the characters viz., panicle weight per plant, panicle index, biological yield per plant, harvest index, number of productive tiller per plant, spikelet density, panicle length, spikelet fertility and 1000-grain weight might be considered. On the basis of PC score, JNPT 810, JNPT 754, JNPT 800, JNPT 752, JNPT 811, JNPT 751, JNPT 748, JNPT 820, JNPT 822 and JNPT 830 were the selected 10 promising lines for both yield and quality attributes.

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