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Character Association and Path Analysis for Yield and Component Traits in *Boro* Rice

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Abstract

The experiments were conducted during *kharif* of 1999. The materials comprised the 22 rice genotypes including the check Prabhat and were sown in randomized block design with three replications in *kharif.* Nine characters were included in the study to estimate extent of genetic variability and character association to evaluate direct and indirect effects including selection indices and effect of different season on the genotypes. ANOVA revealed the existence of variability amongst the experimental materials for all the nine characters. For most of the characters low to moderate GCV was observed and high heritability coupled with high genetic advance have been practices. Grain yield exhibited high degree of positive correlation and high positive direct effect with number of fertile grain per panicle, leaf area and thousand grain weight in boro season. Selection indices can be constructed on the basis of all the characters under study for grain yield and entry viz. ES-18-11-7-1-1-2-1, RAU 1345-1-2-1-1, IR 56383-77-1-1, Turanta and bhat were found to be high yielder.

Key words : Boro rice, Heritability, Correlation, Path analysis, Yield.

Rice is most important cereal crop of Bihar. More than 70% of the total rice area comes under rainfed low land condition, which remains flooded for 2—3 months. Farmers are unable to have the good harvest of rice even though they are dependent for their 90% calories requirements only from rice. Therefore, there is a great need to have a good and assured harvest of rice only from upland and midland which comprise about 30% of the area. For obtaining higher productivity from any ecosystem, genetic improvement is required. The knowledge on the nature and magnitude of genetic variation governing the quantitative characters like yield and its components is essential for formulating effecting genetic improvement program. Keeping these in view the present experiment was conducted during *kharif* of 1999 with 22 early rice genotypes including the check Prabhat.

Methods

The investigation in early rice (*Oryza sativa* L.) was carried out at the Research Farm of Rajendra Agricultural University, Bihar, Pusa, during *boro* of 2000. The experimental material comprised 22 genotypes of rice including the check Prabhat. The experiments were conducted in randomized complete block design with three replications. Data of the five randomly selected plants were recorded for the characters viz. number of tillers per hill, days to 50% flowering, plant height, panicle length, number of fertile grain per panicle, number of sterile grain per panicle, flag leaf area, 1000-grain weight, cold tolerance and the data were analyzed the following methods given by Panes and Sukhatme (1) for ANOVA and correlation and path were analyzed by Wright (2), Deway and Lu (3).

Results and Discussion

All the genotypes showed the significant difference for all the characters (Tables 1—12). For number of tiller per hill varied from 8.67 (RAU 1345-1-7) to 16.60 (ES 29-3-3-1) having the general mean of 11.92 ± 0.86. Three entries namely ES 29-3-1-3-1 (16.60), NDR 1025-3 (16.53) and IR 56383-77-1-1 (16.43) were found to be significantly superior to the best check Heera (13.73) in *boro* season. For the trait days to 50% flowering, in *boro* season range varied from 136.33 days (Heera) to 175 days Boro 3-II-B-8-

Table 1. Analysis of variance for nine characters in *kharif*, *boro* Season and pooled.

	Sources of variation/characters	Mean sum of square Replication (df = 2)	Treatment (df = 21)	Error (df = 42)
		***Kharif* Season**		
1.	No. of tiller per hill	2.57	4.80**	0.67
2.	Days to 50% flowering	2.17	279.77**	0.25
3.	Plant height (cm)	90.16	325.71**	99.45
4.	Panicle length (cm)	3.44	25.89**	4.97
5.	No. of fertile grains per panicle	24.45	427.53**	19.55
6.	No. of sterile grains per panicle	14.90	922.09**	9.06
7.	Leaf area (cm)	3.79	52.04**	2.34
8.	Thousand grain weight (g)	0.47	38.02**	0.21
9.	Grain yield (q/ha)	73.14	77.09**	13.92
		***Boro* Season**		
1.	No. of tillers per hill	0.51	18.04**	2.25
2.	Days to 50% flowering	2.81	339.54**	1.63
3.	Plant height (cm)	1.25	343.88**	12.47
4.	Panicle length (cm)	5.41	31.43**	4.10
5.	No. of fertile grains per panicle	121.31	744.98**	44.09
6.	No. of sterile grains per panicle	64.47	908.47**	46.94
7.	Leaf area (cm^2)	10.05	143.92**	4.80
8.	Thousand grain weight (g)	0.37	16.50**	0.10
9.	Cold tolerance	3.81	6.97**	0.64
10.	Grain yield (q/ha)	34.50	781.86**	5.23
		Pooled Mean Sum of Square *Kharif* Season		
1.	No. of tiller per hill	152.07	11.06**	0.20
2.	Days to 50% flowering	0.48	260.13**	83.33
3.	Plant height (cm)	50.11	320.21**	68.23
4.	Panicle length (cm)	4.11	27.61**	4.52
5.	No. of fertile grains per panicle	67.81	546.52**	21.82
6.	No. of sterile grains per panicle	9.33	790.43**	38.06
7.	Leaf area (cm^2)	14.30	75.71**	3.36
8.	Thousand grain weight (g)	3.42	21.69**	2.88
9.	Grain yield (q/ha)	100.18	273.17**	45.25

1 with the general mean of 155.45 ± 0.73. For the character plant height (cm) in the *boro* season range varied from 59.86 (ES 18-11-2-17-1-1-2-1) to 101.70 cm (Boro 3-II-B-8-1) with the general mean 72.71 ± 2.03. None of the genotypes was found dwarfer to the dwarf check Heera (60.36 cm). In *boro* season panicle length varied from 13.30 (RAU 1345-2) to 29.36 cm (*Boro* 3-II-B-8-1) with the general mean of 20.08 ± 1.16. Four genotypes viz. Boro 5-IB-6-3-3-4-1-1-1 (24.96 cm), Boro 3-II-B8-1 (29.36 cm), IR 56383-77-1-1 (23.56 cm), and NDR 1025-3 (23.13 cm) were found to be significantly superior to the best check Prabhat (19.20 cm). For the character number of fertile grain per panicle in *boro* season range varied from 47.93 (ES 18-11-2-17-1-1-2-1) to 116.86 (Boro 3-II-B-8-1) with the general mean of 74.84 ± 3.83. Three entries namely Boro 3-II-B-8-1 (116.86), RAU 1345-1-7 (111.50 and Boro 5-B-6-3-3-4-1-1-1 (94.80) were found to be significantly superior to the check Turanta (82.20). For no. of sterile grain per plants, none of the genotype showed the significant superiority to check Heera (22.76). For the trait leaf area (cm^2) in *boro* season range varied from 8.81 (ES 29-3-3-1) to 42.50 cm^2 (Boro 5-IB-6-3-3-4-1-1-1) with the general mean

Table 2. Mean performance of 22 genotypes of rice in *kharif* season.

	Genotypes	No. of tiller per hill	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	No. of fertile grain per panicle	No. of sterile grain per panicle	Leaf area (cm^2)	1000 grain weight (g)	Yield (q/ha)
1.	ES 21-2-1	8.63	64.66	97.93	21.70	71.50	14.00	18.76	26.79	41.73
2.	ES 29-3-3-1	9.78	62.66	90.73	21.20	64.26	20.73	17.52	26.70	37.56
3.	RAU 1344-3-2	7.87	70.33	92.93	13.93	60.86	17.33	17.03	26.30	40.56
4.	RAU 1345-5-5-1	9.23	64.33	91.33	21.33	81.86	20.13	21.66	26.76	42.23
5.	RAU 1344-4-1	7.90	69.33	96.73	21.50	74.40	18.20	20.19	24.40	35.90
6.	RAU 1345-2	6.95	63.66	62.66	20.83	67.90	13.60	17.77	16.32	38.16
7.	RAU 1345-4-1	6.87	64.66	89.30	22.10	67.00	15.86	18.73	17.80	40.00
8.	RR 151-3	5.88	51.66	107.13	21.26	61.93	36.13	13.79	18.30	31.50
9.	RAU 1344-7	7.37	70.66	85.66	20.53	82.40	18.93	17.18	17.50	35.80
10.	*Boro* 3-II-B-8-1	5.25	81.00	105.13	25.76	65.43	66.00	16.01	18.81	30.16
11.	ES-18-11-2-17-1-1-2-1	8.58	76.66	96.06	19.46	96.83	51.66	13.89	18.34	37.20
12.	RAU 1346-4-2-1	7.16	63.33	88.43	21.06	72.40	20.53	14.33	18.99	31.20
13.	RAU 1345-1-7	7.46	62.66	88.43	21.33	74.46	12.76	15.14	17.54	33.00
14.	RAU 1345-2-1-3	9.56	65.00	92.23	23.16	81.93	24.33	15.38	20.48	29.23
15.	RAU 1345-1-2-1-1	8.30	65.00	88.66	19.93	80.86	14.93	14.22	19.10	34.40
16.	IR 56383-77-1-1	7.85	76.00	90.26	22.40	92.40	25.60	18.05	18.11	39.24
17.	ES-18-11-2-17-1-1	9.64	72.33	94.00	20.93	80.40	23.73	21.58	18.24	31.23
18.	NDR 1025-3	7.49	76.00	83.46	24.00	72.30	20.30	27.63	22.48	32.73
19.	*Boro* 5-IB-6-3-3-4-1-1-1	7.39	93.66	113.00	29.63	83.66	76.66	27.87	24.82	44.23
20.	Heera	7.56	49.66	73.86	18.03	47.33	7.70	12.34	18.28	24.70
21.	Turanta	6.02	56.00	91.16	18.56	95.66	15.43	12.99	20.10	36.83
22.	Prabhat (c)	9.72	67.66	87.50	20.66	78.80	15.60	15.87	22.82	42.93
	GM	7.83	64.85	83.04	21.42	75.00	25.00	17.00	20.06	35.95
	SE	0.47	0.28	5.75	1.28	2.55	1.73	0.88	0.26	2.15
	CV %	10.45	0.73	10.93	10.45	5.88	12.03	8.67	2.21	10.38
	CD %	1.36	0.82	16.61	3.71	7.36	5.01	2.54	0.76	6.21

of 15.71 ± 1.26. These entries namely Boro 3-II-B-8-1 (26.76 cm^2) NDR 1025-3 (18.17 cm^2 and Boro 5-IB-6-3-3-4-1-1-1 (42.50 cm^2) were found to be significantly superior to the check Prabhat (14.53 cm^2). In *boro* season thousand grain weight (g) varied from 17.42 g (ES 18-11-2-17-1-1-2-1) to 26.74 g (ES 21-2-1) with general mean of 19.3 ± 0.18. Three entries viz., ES 21-2-1 (26.74 g), RAU 1344-4-1 (25.13 g) and Boro 5-IB-6-3-3-4-1-1-1 (24.72 g) were found to be significantly superior to the check Turanta (23.45 g). In *boro* season for the cold tolerance score range varied from 1.67 (Boro 3-II-B-8-1) to 7.0 (RR 151-3), RAU 1345-7 and ES 18-11-2-17-1-1-2-1 with general mean of 4.2 ± 0.46. Only two entries namely Boro 3-II-B-8-1 (1.67) and Boro 5-IB-6-3-3-4-1-1-1 (1.67) were observed to be superior to the check Turanta (3.0). Grain yield (q/ha) in *boro* season range varied from 34.83 (ES 18-11-2-17-1-1-2-1) to 96.60 q/h. (Boro 3-II-B-8-1) with the general mean of 65.65 ± 1.31. Six entries viz., RAU 1345-3-2 (72.40 q/ha), RAU 1345-5-5-1 (90.10 q/ha), Boro B-II-B-8-1 (96.50 q/ha), RAU 1345-2-1-3 (70.76 q/ha), RAU 1345-1-2-1-1 (78.70 q/ha) and Boro 5-IB-6-3-3-4-1-1-1 (89.06 q/ha) were found to be significantly superior to the check Prabhat (67.43 q/ha). Genetic variability for all nine characters was studied in *boro* season with the help of different genetic parameters viz., genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (h^2), genetic advance (GA) and GA as per cent of mean.

For all the characters, PCV was higher than GCV in *boro* season. The characters having the GCV up to 15% have been grouped in low genotypic variation those having 16.00 to 25.00% in moderate genotypic variability and ones having GCV of more than 25.00% are kept in high genotypic variability class.

Table 3. Mean performance of 22 genotypes of rice of *boro* season.

	Genotypes	No. of tiller per hill	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	No. of fertile grain per panicle
1.	ES 21-2-1	11.36	147.00	74.13	18.50	63.66
2.	ES 29-3-3-1	16.60	142.33	61.53	16.93	61.53
3.	RAU 1344-3-2	15.13	156.66	75.26	20.36	83.86
4.	RAU 1345-5-5-1	10.23	144.33	67.23	20.30	85.83
5.	RAU 1344-4-1	10.83	164.00	73.20	21.43	78.73
6.	RAU 1345-2	12.20	152.00	68.03	13.30	73.93
7.	RAU 1345-4-1	11.06	15.50	64.13	19.20	77.13
8.	RR 151-3	9.80	140.00	89.30	19.63	64.46
9.	RAU 1344-7	15.03	165.00	76.10	21.13	77.90
10.	*Boro* 30-II-B-8-1	10.80	175.00	101.70	29.36	116.86
11.	ES-18-11-2-17-1-1-2-1	9.23	144.33	59.86	16.00	47.93
12.	RAU 1346-4-2-1	14.16	156.33	67.63	19.43	83.66
13.	RAU 1345-1-7	8.67	167.00	67.93	20.20	111.50
14.	RAU 1345-2-1-3	13.40	157.00	67.96	20.26	85.90
15.	RAU 1345-1-2-1-1	12.00	143.66	65.13	19.50	80.40
16.	IR 56383-77-1-1	16.43	166.33	80.36	23.56	70.90
17.	ES-18-11-2-17-1-1	14.13	162.00	72.16	19.00	82.13
18.	NDR 1025-3	16.53	162.00	71.63	23.13	79.03
19.	*Boro* 5-IB-6-3-3-4-1-1-1	11.10	168.33	95.66	24.96	94.80
20.	Heera	13.73	136.33	60.36	18.00	62.10
21.	Turanta	10.30	151.33	69.53	18.56	82.20
22.	Prabhat (c)	10.83	163.00	70.80	19.20	64.20
	GM	11.92	155.45	72.71	20.08	74.84
	SE	0.86	0.73	2.03	1.16	3.83
	CV %	12.07	0.82	4.85	10.08	8.45
	CD %	2.49	2.12	5.88	3.37	11.06

Table 3. Continued.

	Genotypes	No. of sterile grain per panicle	Leaf area (cm^2)	1000 grain weight (g)	Cold tolerance	Yield (q/ha)
1.	ES 21-2-1	16.83	14.94	26.74	4.33	73.70
2.	ES 29-3-3-1	22.13	8.81	20.22	4.33	70.30
3.	RAU 1344-3-2	18.03	15.12	19.67	3.67	72.40
4.	RAU 1345-5-5-1	26.16	12.66	18.20	3.00	90.10
5.	RAU 1344-4-1	25.66	16.73	25.13	6.33	51.20
6.	RAU 1345-2	32.16	12.98	19.82	4.33	67.50
7.	RAU 1345-4-1	22.76	11.23	18.76	5.00	65.90
8.	RR 151-3	30.63	15.56	20.43	7.00	38.16
9.	RAU 1344-7	22.80	13.73	20.50	7.00	43.56
10.	*Boro* 3-II-B-8-1	79.06	26.76	20.45	1.67	96.60
11.	ES-18-11-2-17-1-1-2-1	51.63	11.79	17.42	7.00	34.83
12.	RAU 1346-4-2-1	22.10	12.18	18.47	3.67	71.20
13.	RAU 1345-1-7	40.56	14.73	20.52	5.00	59.10
14.	RAU 1345-2-1-3	16.73	13.79	20.43	3.00	78.76
15.	RAU 1345-1-2-1-1	17.40	10.75	19.29	3.00	78.70
16.	IR 56383-77-1-1	45.06	15.52	20.82	4.33	55.06
17.	ES-18-11-2-17-1-1	57.20	16.13	20.60	4.33	67.40
18.	NDR 1025-3	10.63	18.17	18.82	3.67	64.40
19.	*Boro* 5-IB-6-3-3-4-1-1-1	70.63	42.50	24.72	1.67	89.06
20.	Heera	22.76	13.18	20.36	4.33	51.80
21.	Turanta	43.86	13.96	23.45	3.00	55.50

Table 3. Continued.

	Genotypes	No. of sterile grain per panicle	Leaf area (cm^2)	1000 grain weight (g)	Cold tolerance	Yield (q/ha)
22.	Prabhat (c)	32.30	14.53	19.28	4.33	67.43
	GM	29.85	15.71	19.73	4.2	65.56
	SE	3.95	1.26	0.18	0.46	1.31
	CV %	21.31	13.94	1.52	18.77	3.48
	CD %	11.41	3.64	0.52	1.32	3.80

In *boro* season low GCV was observed for the characters, days to 50% flowering, plant height, number of sterile grains per panicle and thousand grains weight. Moderate GCV was observed for number of tiller per hill, panicle length, number of fertile grains per panicle, leaf area and yield.

All the characters have exhibuted high heritability coupled with high genetic advance indicating the preponderance of additive type of gene action, suggesting that selection can be made in early generation in segregating generation.

Genotypic and phenotypic correlation coefficient were worked out for all the character combinations. In all most of the trait combination genotypic

Table 4. Pooled mean performance of 22 genotypes of rice on the basis of *kharif* and *boro* seasons.

	Genotypes	No. of tiller per hill	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	No. of fertile grain per panicle	No. of sterile grain per panicle	Leaf area (cm^2)	1000 grain weight (g)	Yield (q/ha)
1.	ES 21-2-1	9.99	105.83	86.03	20.10	67.58	15.41	16.85	26.76	57.71
2.	ES 29-3-3-1	13.19	102.50	76.13	19.06	62.90	21.43	13.17	23.46	53.93
3.	RAU 1344-3-2	11.50	113.50	84.10	17.15	72.36	17.68	16.07	22.98	51.48
4.	RAU 1345-5-5-1	9.73	104.33	79.28	20.81	83.85	23.15	17.16	22.48	66.16
5.	RAU 1344-4-1	9.36	116.66	84.96	21.46	76.56	21.93	18.46	24.77	43.55
6.	RAU 1345-2	9.57	108.16	65.35	17.06	70.91	22.80	15.38	18.07	52.83
7.	RAU 1345-4-1	8.96	109.83	76.71	20.65	72.06	19.31	14.98	18.28	52.95
8.	RR 151-3	7.84	95.83	98.21	20.45	63.20	33.38	14.67	19.36	34.83
9.	RAU 1344-7	11.20	118.00	80.88	20.83	80.15	20.86	15.45	19.00	39.68
10.	*Boro* 3-II-B-8-1	8.02	128.00	103.41	27.56	91.15	72.53	21.38	19.65	63.38
11.	ES-18-11-2-17-1-1-2-1	8.90	110.00	77.96	17.73	72.38	51.65	12.84	17.88	36.01
12.	RAU 1346-4-2-1	10.66	109.00	78.03	20.25	78.03	21.31	13.25	18.73	51.20
13.	RAU 1345-1-7	8.06	114.83	78.18	20.76	92.98	26.66	14.93	19.03	46.05
14.	RAU 1345-2-1-3	11.48	111.00	80.10	21.71	83.91	20.53	14.53	20.46	54.00
15.	RAU 1345-1-2-1-1	10.15	104.33	76.90	19.71	80.63	16.16	12.49	19.20	56.55
16.	IR 56383-77-1-1	12.14	121.16	85.81	22.98	81.65	35.33	16.78	19.46	47.13
17.	ES-18-11-2-17-1-1	11.88	117.16	83.08	19.96	81.26	30.46	18.85	19.42	49.31
18.	NDR 1025-3	12.01	119.00	77.55	23.56	75.66	15.46	22.90	20.65	50.06
19.	*Boro* 5-IB-6-3-3-4-1-1-1	9.24	131.00	104.33	27.30	89.03	73.65	35.21	24.77	66.65
20.	Heera	10.64	93.00	67.11	18.01	54.71	16.23	12.76	19.32	38.25
21.	Turanta	8.16	103.66	80.35	18.56	88.93	29.65	13.48	21.77	46.16
22.	Prabhat (c)	10.28	115.33	79.15	19.93	71.50	22.95	15.20	21.05	55.18
	GM	10.13	111.45	81.98	20.70	76.88	28.56	16.67	20.75	50.60
	SE	0.085	2.048	0.284	0.107	0.2833	0.2659	0.094	0.019	0.155
	CV %	6.890	5.030	5.260	6.120	4.140	9.505	6.938	3.101	3.514
	CD %	0.798	0.633	4.880	1.390	3.694	3.457	1.234	0.257	2.021

Table 5. Genetic parameters of nine characters in different season of rice. GCA = Genotypic coefficient of variation ; PCV = Phenotypic coefficient of variation ; h^2% = Heretability in broad sense ; GA = Genetic advance ; GA % = Genetic advance percentage of mean.

		Kharif season					*Boro* season				
	Season/characters	GCV %	PCV %	h^2 %	GA	GA %	GCV %	PCV %	h^2 %	GA	GA %
1.	No. of tiller per hill	14.72	16.15	86.25	24.9	318.00	19.24	20.56	87.52	47.24	396.30
2.	Day to 50% flowering	14.88	14.89	99.91	198.83	306.59	6.82	6.84	99.52	218.62	140.63
3.	Plant height (cm)	10.45	12.54	69.46	178.89	215.42	14.58	14.85	96.44	218.46	300.45
4.	Panicle length (cm)	12.33	13.71	80.88	54.42	254.06	15.05	16.11	87.29	62.27	310.10
5.	No. of fertile grain per panicle	15.50	15.87	95.43	240.23	319.45	20.42	21.05	94.08	314.86	420.71
6.	No. of sterile grain per Panicle	54.27	54.54	99.01	359.36	1118.10	13.79	13.97	94.83	349.08	1169.44
7.	Leaf area (cm^2)	23.93	24.49	95.50	83.82	493.05	16.61	44.08	96.66	140.27	892.07
8.	1,000 grain weight (g)	17.01	17.06	98.38	73.11	8501.16	11.85	11.88	99.45	48.18	244.19
9.	Cold tolerance	–	–	–	–	–	59.90	62.85	95.30	51.82	123.40
10.	Yield (q/ha)	12.76	14.09	81.83	94.50	731.18	24.56	24.62	99.32	331.42	505.52

Pooled Basis

	Character	GCV	PCV	h^2 %	GA	GA %
1.	No. of tiller per hill	6.4468	7.0338	84.0063	13.4532	132.8055
2.	Days to 50% flowering	2.1089	2.1188	99.0681	48.4484	43.4436
3.	Plant height (cm)	2.7080	3.1584	73.0950	45.6024	55.6250
4.	Panicle length (cm)	3.1733	3.9931	63.1525	13.5381	65.3698
5.	No. of fertile grain per panicle	7.2824	7.4849	94.6628	115.3498	150.0192
6.	No. of sterile grain per panicle	10.0001	10.9117	83.9947	58.8568	206.0091
7.	Leaf area (cm^2)	9.5512	9.8900	92.7081	32.7008	136.1655
8.	1,000 grain weight (g)	4.8031	4.8238	99.1416	20.5308	96.986
9.	Yield (q/ha)	8.9340	9.0477	97.4851	93.5212	184.0243

Table 6. Phenotypic (upper value) and genotypic (lower value) correlation coefficients between different character combination among nine characters in *kharif* season. *Significant at $P = 0.05$, ** Significant at $P = 0.01$.

	Characters		ch-1	ch-2	ch-3	ch-4	ch-5	ch-6	ch-7	ch-8	ch-9
1.	No. of tiller per hill	P	1.000	0.041	0.025	0.006	0.195	0.245	0.391	0.083	0.195
		G	1.000	0.047	0.183	0.025	0.205	0.309	0.470	0.211	0.260
2.	Days to 50% flowering	P		1.000	0.347	0.514*	0.384	0.697**	0.178	0.621**	0.032
		G		1.000	0.522	0.665	0.407	0.707	0.179	0.668	0.419
3.	Plant height (cm)	P			1.000	0.296	0.171	0.549**	0.254	0.166	0.131
		G			1.000	0.589	0.263	0.834	0.418	0.255	0.244
4.	Panicle length (cm)	P				1.000	0.144	0.142	0.022	0.451*	0.099
		G				1.000	0.205	0.730	0.039	0.681	0.086
5.	No. of fertile grain per panicle	P					1.000	0.185	0.068	0.112	0.434*
		G					1.000	0.221	0.079	0.103	0.481
6.	No. of sterile grain per panicle	P						1.000	0.021	0.266	0.075
		G						1.000	0.019	0.299	0.095
7.	Leaf area (cm^2)	P							1.000	0.419	0.450*
		G							1.000	0.447	0.588
8.	1,000 grain weight (g)	P								1.000	0.424*
		G								1.000	0.462
9.	Yield (q/ha)	P									
		G									

Table 7. Phenotypic (upper value) and genotypic (lower value) correlation coefficients between different character combinations among ten characters in *boro* season. *Significant at $P = 0.05$, **Significant at $P = 0.01$.

	Characters		ch-1	ch-2	ch-3	ch-4	ch-5	ch-6	ch-7	ch-8	ch-9	ch-10
1.	No. of tiller	P	1.000	0.075	-0.040	0.051	-0.139	-0.291	-0.141	-0.123	0.087	0.039
	per hill	G	1.000	0.073	-0.138	0.067	-0.199	-0.474	-0.161	-0.167	0.110	0.052
2.	Days to 50%	P		1.000	0.537**	0.602**	0.613**	0.435*	0.176	0.526*	0.197	0.265
	flowering	G		1.000	0.566	0.724	0.679	0.474	0.179	0.553	0.249	0.266
3.	Plant height	P			1.000	0.655**	0.457*	0.599**	0.348	0.746**	0.255	0.277
	(cm)	G			1.000	0.852	0.501	0.655	0.378	0.798	0.296	0.310
4.	Panicle	P				1.000	0.532*	0.406	0.165	0.556**	0.383	0.381
	length (cm)	G				1.000	0.722	0.536	0.205	0.738	0.459	0.450
5.	No. of fertile											
	grain per	P					1.000	0.361	0.093	0.437**	0.487**	0.539**
	panicle	G					1.000	0.431	0.097	0.496	0.594	0.603
6.	No. of sterile											
	grain per	P						1.000	0.151	0.617**	0.268	0.161
	panicle	G						1.000	0.161	0.713	0.285	0.179
7.	Leaf area	P							1.000	0.423*	0.092	0.059
	(cm^2)	G							1.000	0.447	0.101	0.661
8.	1,000 grain	P								1.000	0.399	0.492*
	weight (g)	G								1.000	0.497	0.515
9.	Cold tole-	P									1.000	0.757**
	rance	G									1.000	0.932
10.	Yield (q/ha)											

correlation coefficient was higher in magnitude than the phenotypic correlation coefficient. The days to 50% flowering exhibited positive and significant correlation with panicle length, number of sterile grains per panicle and thousand grain weight, like wise plant height also exhibited positive correlation coefficient with number of sterile grains per panicle and panicle length have significant correlation

Table 8. Pooled phenotypic (upper value) and genotypic (lower value) correlation coefficient between different characters combination among nine characters in rice. *Significant at $P = 0.05$, **Significant at $P = 0.01$.

	Characters		ch-1	ch-2	ch-3	ch-4	ch-5	ch-6	ch-7	ch-8	ch-9
1.	No. of tiller	P	1.000	0.028	0.064	0.083	-0.192	-0.187	-0.084	0.150	0.135
	per hill	G	1.000	0.080	0.398	0.381	-0.444	-0.543	-0.078	0.469	-0.025
2.	Days to 50%	P		1.000	0.467*	0.629**	0.609**	0.567**	0.693**	-0.047	0.287
	flowering	G		1.000	0.614	0.802	0.676	0.589	0.739	0.057	0.359
3.	Plant height	P			1.000	0.492	0.341	0.618**	0.530*	0.042	0.112
	(cm)	G			1.000	0.854	0.475	0.833	0.715	0.059	0.103
4.	Panicle length	P				1.000	0.361	0.565**	0.667**	0.005	0.332
	(cm)	G				1.000	0.501	0.745	0.938	0.025	0.524
5.	No. of fertile										
	grain per	P					1.000	0.392	0.373	-0.043	0.254
	panicle	G					1.000	0.479	0.434	-0.124	0.393
6.	No. of sterile										
	grain per	P						1.000	0.574**	-0.067	0.141
	panicle	G						1.000	0.649	-0.115	0.213
7.	Leaf area (cm^2)	P							1.000	0.227	0.340
		G							1.000	0.257	0.512
8.	1000 grain	P								1.000	0.381
	weight (g)	G								1.000	0.560
9.	Yield (q/ha)	P									
		G									

Table 9. Genotypic direct (diagonal) and indirect effect of eight characters on yield in *kharif* season. Residual effect = 0.360.

	Characters	1	2	3	4	5	6	7	8	Correlation with yield
1.	No. of tiller per hill	-0.451	-0.348	-1.288	-0.103	-0.038	1.408	-0.048	0.386	0.260
2.	Days to 50% flowering	0.292	-0.181	-2.469	-0.091	0.151	1.661	-0.018	0.900	0.419
3.	Plant height (cm)	0.227	-0.231	-1.453	-0.155	0.208	1.454	-0.049	0.085	0.244
4.	Panicle length (cm)	0.227	-0.016	0.452	0.039	-0.824	-0.615	-0.015	1.013	0.086
5.	No. of fertile grain per panicle	1.109	-0.141	-0.649	-0.032	-0.169	0.442	-0.007	-0.171	0.481
6.	No. of sterile grain per panicle	0.246	-0.246	-2.059	-0.113	0.255	1.992	-0.022	0.042	0.095
7.	Leaf area (cm^2)	0.115	-0.232	-0.629	-0.105	-0.174	0.597	0.072	0.964	0.588
8.	1000 grain weight (g)	-0.087	-0.062	-1.031	-0.006	-0.387	0.038	-0.032	2.156	0.462

with thousand grain weight. Number of fertile grains per panicle, leaf area and thousand grain weight exhibited significant and positive correlation with grain weight.

It suggests a fairly inherent association between the characters studied. Phenotypic expressions were being suppressed more likely under the influence of environment, it is also suggested by Chauhan (4) and Singh (5). Therefore, selection on the basis of these traits may lead to significant increasing trend in the productivity without affecting the other traits Satyavathi.

In the present investigation the path coefficient analysis reveals that thousand grain weight exhibited high positive direct effect on grain yield suggesting that selection for this trait will be rewarding in the yield improvement. Rangasamy (7) and Satyavathi (6) observed similar findings. In *boro* season none of the traits exhibited significant multiple regression, therefore selection index cannot be

Table 10. Genotypic direct (diagonal) and indirect effect of nine characters on yield in *boro* season. Residual effect = 0.441.

	Characters	1	2	3	4	5	6	7	8	9	Correlation with yield
1.	No. of tiller per hill	-0.008	-0.602	-1.039	2.079	-0.646	-0.026	0.128	0.270	0.112	0.052
2.	Days to 50% flowering	0.016	-0.341	-1.834	2.447	-0.477	-0.036	0.270	0.390	0.133	0.266
3.	Plant height (cm)	-0.008	-0.436	-1.562	2.872	-0.686	-0.030	0.147	0.361	0.206	0.310
4.	Panicle length (cm)	0.023	-0.409	-0.921	2.072	-0.951	-0.024	0.069	0.243	0.049	0.450
5.	No. of fertile grain per panicle	-0.116	-0.044	0.254	0.194	0.189	0.026	-0.115	-0.082	0.128	0.603
6.	No. of sterile grain per panicle	0.055	-0.286	-1.202	1.541	-0.410	-0.056	0.115	0.349	0.046	0.179
7.	Leaf area (cm^2)	0.018	-0.108	-0.694	0.591	-0.092	-0.009	0.313	0.129	0.022	0.061
8.	1,000 grain weight (g)	0.019	-0.333	-1.464	2.120	-0.472	-0.039	0.319	0.489	0.223	0.515
9.	Cold tolerance	0.033	0.150	0.543	-1.319	0.105	0.005	0.355	-0.243	0.448	0.932

Table 11. Pooled genotypic direct (diagonal) and indirect effect of eight characters on yield. Residual effect = 0.56.

Characters	1	2	3	4	5	6	7	8	Correlation with yield
1. No. of tiller per hill	-1.670	- 0.121	0.138	0.774	0.263	0.312	-0.142	0.419	- 0.025
2. Days to 50% flowering	0.133	1.517	- 0.214	- 1.631	- 0.400	- 0.339	1.343	- 0.051	0.359
3. Plant height (cm)	0.664	0.931	- 0.348	- 1.763	- 0.281	- 0.479	1.299	0.052	0.103
4. Panicle length (cm)	0.636	1.216	- 0.297	- 2.033	- 0.296	- 0.428	1.704	0.022	0.524
5. No. of fertile grain per panicle	0.741	1.025	- 0.165	- 1.081	- 0.592	- 0.275	0.788	- 0.101	0.393
6. No. of sterile grain per panicle	0.907	0.893	- 0.290	- 1.515	- 0.283	- 0.575	1.179	- 0.102	0.213
7. Leaf area (cm^2)	0.130	1.121	- 0.249	- 1.907	- 0.257	- 0.373	1.817	0.229	0.512
8. 1000 grain weight (g)	-0.783	- 0.086	- 0.020	- 0.051	- 0.073	- 0.066	0.467	0.894	0.560
9. Yield (q/ha)									

formulated with the help of multiple regression analysis.

Conclusion

The experimental materials showed significant difference for all the characters and high heritability coupled with high genetic advance suggested that preponderance of additive gene action. Thousand grain weight and cold tolerance score of the time of selection should be considered to enhance the yield of *boro* rice.

Table 12. Relative ranking of genotypes on the basis of grain yield and selection score in *kharif* season. Rank correlation coefficient = 0.73.

	Genotypes	Grain yield (q/ha)	Rank as per grain yield	Selection score on the basis of selection index	Rank as per selection index
1.	ES 21-2-1	41.73	4	16.19	14
2.	ES 29-3-3-1	37.56	9	15.54	18
3.	RAU 1344-3-2	40.56	5	15.23	19
4.	RAU 1345-5-5-1	42.23	3	16.98	9
5.	RAU 1344-4-1	35.90	12	16.34	13
6.	RAU 1345-2	38.16	8	15.91	15
7.	RAU 1345-4-1	40.00	6	15.70	17
8.	RR 151-3	31.50	17	15.73	16
9.	RAU 1344-7	35.80	13	17.58	7
10.	*Boro* 3-II-B-8-1	30.16	20	15.73	16
11.	ES-18-11-2-17-1-1-2-1	37.20	10	19.56	2
12.	RAU 1346-4-2-1	31.20	19	16.82	12
13.	RAU 1345-1-7	33.00	15	16.95	10
14.	RAU 1345-2-1-3	29.23	21	17.74	6
15.	RAU 1345-1-2-1-1	34.40	14	17.76	5
16.	IR 56383-77-1-1	39.20	7	18.57	3
17.	ES-18-11-2-17-1-1	31.23	18	16.83	11
18.	NRD 1025-3	32.73	16	15.94	15
19.	*Boro* 5-IB-6-3-3-4-1-1-1	44.23	1	17.27	8
20.	Heera	24.70	22	14.77	20
21.	Turanta	36.83	11	20.50	1
22.	Prabhat (c)	42.93	2	18.13	4

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