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GENETICS OF SOME VEGETATIVE CHARACTERS IN RICE (*ORYZA SATIVA* L.) UNDER PHOSPHORUS-STRESS CONDITION

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ABSTRACT

In a one-way diallel cross (7X7), the parents included were of different stature, tillering habit and canopy area. Unlike the dwarfs, tall local parents had high leaf area with low tillering capacity. Both additive and nonadditive gene actions were involved, with the preponderance of the former. Incomplete dominance, dominance, overdominance and nonallelic interactions were evident in various cases.

Key words: Rice, *O. sativa*, vegetative traits, P-stress.

Phosphorus availability is affected in the lateritic soil at low pH. This reduces plant growth. Variability in respect of P intake capacity and differential tolerance level were described by IRRI workers [1]. They also identified tolerant varieties. The genetic architecture is however yet to be clearly understood. To obtain basic information on this aspect a study was undertaken in P-tolerant rice varieties.

MATERIALS AND METHODS

Three P-tolerant lines, IR 28, IR 29 and IR 30, obtained from IRRI and four adapted local varieties, Khonorullo, Mirikrak, Pawnbuh and Ngoba, were crossed in one-way diallel cross. The F_1 along with parents were sown in randomised block design. Plant and row distances were 20 cm. In the fertilizer schedule (N : P : K = 20 : 0 : 30 kg/ha), phosphorus application was withdrawn. Data collected on plant height, tiller number, leaf area, flag leaf area, fresh and dry shoot weight were analysed following Griffing's Model 1, Method 2 [2].

RESULTS AND DISCUSSION

Precropping analysis of soil indicated acidic nature (pH 5.0), with low available phosphorus (11.2 kg/ha). Available K (44.8 kg/ha) and organic matter (6.79%) were not limiting

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for plant growth. The low P status of the soil did not lead to visible abnormal plant growth. Phosphorus content in the plant tissue was also low (0.13 – 0.19%) but above the critical limit (0.1%) for deficiency symptoms as per Yoshida et al. [3].

Significant mean squares for treatment for all characters reflected the genetic diversity of the parental lines and their hybrids (Tables 1, 2). The gca and sca values indicated additive and nonadditive gene actions (Tables 3, 4). The gca : sca ratio more than unity suggested a predominant role of additive gene effect for all characters.

Table 1. Mean values of vegetative characters of parents and hybrids of rice

Parent/cross	Plant height (cm)	Tiller number	Leaf area (cm^2)	Flag leaf area (cm^2)	Shoot wt. (fresh) (g)	Shoot wt. (dry) (g)
IR 28	72.3	14.0	1598.4	158.4	56.2	17.8
IR 28 X IR 29	73.1	11.9	1973.0	127.2	48.5	11.9
IR 28 X IR 30	87.6	15.7	1963.0	215.1	49.2	16.4
IR 28 X Khonorullo	117.8	15.3	3273.0	320.9	77.7	19.1
IR 28 X Mirikrak	126.7	9.0	2903.6	321.9	56.6	19.5
IR 28 XPawnbuh	125.3	16.4	4100.3	356.1	123.9	35.4
IR 28 XNgoba	85.2	17.4	3534.0	359.8	60.4	19.4
IR 29	61.8	14.5	1177.9	168.7	51.1	16.3
IR 29 X IR 30	73.8	18.5	2702.2	259.7	66.1	25.2
IR 29 X Khonorullo	128.4	17.7	3951.1	446.3	133.3	40.3
IR 29 X Mirikrak	119.5	13.3	2841.6	344.8	112.7	35.3
IR 29 X Pawnbuh	120.0	14.9	3738.5	383.0	93.4	30.6
IR 29 X Ngoba	92.7	15.9	2585.2	329.5	77.1	26.4
IR 30	75.0	13.8	1809.6	158.4	50.7	15.5
IR 30 X Khonorullo	104.5	10.5	1970.7	211.1	60.3	19.1
IR 30 X Mirikrak	112.3	12.5	2458.2	375.1	144.1	46.9
IR 30 X Pawnbuh	133.7	16.8	5998.0	467.8	133.6	38.7
IR 30 X Ngoba	83.1	15.0	2366.5	179.5	77.6	19.6
Khonorullo	139.1	7.5	2200.1	146.9	42.4	13.0
Khonorullo X Mirikrak	146.3	10.5	4426.8	276.6	109.3	18.6
Khonorullo X Pawnbuh	171.6	13.3	6157.2	519.7	140.2	42.0
Khonorullo X Ngoba	142.7	12.3	3671.0	318.6	78.3	25.4
Mirikrak	134.4	6.7	2998.0	277.5	119.8	39.8
Mirikrak X Pawnbuh	145.5	11.5	4476.5	380.1	128.4	33.2
Mirikrak X Ngoba	144.8	12.5	4335.6	566.2	149.8	44.5
Pawnbuh	134.9	8.7	3143.3	199.0	62.8	15.2
Pawnbuh X Ngoba	135.2	10.7	4697.3	317.6	112.8	32.3
Ngoba	81.5	17.3	3755.3	301.1	70.7	22.6
CD 5%	9.9	2.1	1025.6	96.8	18.0	6.2
CD 1%	13.2	2.8	1366.4	128.9	23.9	8.2

The local parents are tall, Ngoba is a semidwarf, and the remaining genotypes are dwarf. Tallness expressed itself as an incompletely dominant trait in all cross combinations. All parental lines showed significant gca effect for plant height, the tall parent exhibiting positive effect while the short ones having negative effect. The incomplete dominance of tallness in tall x dwarf crosses observed in this study is in agreement with the earlier findings [4, 5]. The heterotic effect in respect of height and significant sca effect in specific dwarf x dwarf and tall x tall crosses indicated the overdominance effect, as earlier reported by Sivasubramaniam et al. [6] and Ranganathan et al. [7]. Presence of both additive and dominance effects for plant height in rice was also reported from earlier studies [8–10]. The dwarf genotypes produced significantly more tillers than the tall parents (Table 1). The trend of tiller production in the hybrids was similar to that of plant height: the tiller number exceeded the value of parental lines in tall x tall crosses. In dwarf x dwarf and tall x dwarf crosses, the number of tillers was intermediate and nearer to that of the dwarf parents, only sometimes exceeding it. The gca estimates of all the parent lines were significant for tiller number, the dwarf parents showing positive and tall parents showing negative effect. Sca estimates were significant and positive in dwarf x dwarf as well as dwarf x tall crosses.

Table 2. Mean squares for different vegetative characters

Source	d.f.	Plant height	Tiller number	Leaf area	Flag leaf area	Fresh shoot wt.	Dry shoot wt.
Replications	2	102.2	8.7	9636608.0**	10509.3	46.1	2.1
Parents	6	3563.1**	49.2**	2634631.7**	12024.6**	2015.5**	255.0**
Hybrids	20	2222.5**	22.2**	4439160.9**	34760.9**	3494.5**	318.4**
Parents x hybrids	1	5062.5**	68.7**	20700900.1**	294205.8**	16152.6**	1147.8**
Error	54	36.5	1.6	391694.2	3487.8	120.3	14.2
gca	6	3347.6**	22.9**	3447953.0**	13846.5**	2235.4**	167.3**
sca	21	168.8**	6.3**	1003632.8**	12894.2**	919.0**	93 .8**
Error (gca x sca)	126	12.2	0.5	130654.7	1162.6	40.1	4.7
gca/sca		19.8	3.6	3.4	1.1	2.4	1.8

*, ** Significant at 5% and 1% levels, respectively.

The dominant tillering effect of the dwarf genotypes was evident in the tall x dwarf crosses (Table 4). The increased tillering in the tall x tall hybrids may be due to nonallelic interactions, as suggested by the significant positive sca effects in some crosses. High estimates of gca and sca for tiller number and the effect of additive, dominance and nonallelic interactions of genes had been earlier reported by several workers [9–13].

The dwarfs, in general, had significantly lower leaf area (Table 1). Pawnbuh with all other lines produced heterosis for leaf area, and almost similar effect was displayed by the dwarf parents for tillering habit. In flag leaf area too a similar trend was observed. The gca estimates showed that IR 28 and IR 29 gave significant negative, while Pawnbuh and Ngoba gave significant positive effects for both total leaf area and flag leaf area. IR 30 gave significant effects in different directions: positive for leaf area and negative for flag leaf area (Table 3).

Table 3. Estimates of gca effects of parental lines for different vegetative characters

Parent	Plant height	Tiller number	Leaf area	Flag leaf area	Fresh shoot wt.	Dry shoot wt.
IR 28	–16.2**	0.75**	–555.7**	–45.0**	–20.21**	–6.04**
IR 29	–19.5**	1.59**	–644.1**	–23.4*	–8.51**	–1.02
IR 30	–18.0**	1.08**	540.7**	–44.2**	–8.71	–1.61*
Khonorullo	20.3**	1.36**	211.7	–3.9	–2.97	–2.32**
Mirikrak	17.9**	–2.67**	165.9	–44.1**	25.56**	7.35**
Pawnbuh	22.1**	–0.66**	1056.7**	44.4	16.37**	3.47**
Ngoba	–6.6**	1.27**	306.2	27.9**	–1.47	0.15
± Sgi	1.1	0.23	111.5	10.5	1.95	0.67
± S (gi–gj)	1.6	0.35	170.3	16.1	2.98	1.03

*, ** Significant at 5% and 1% levels, respectively.

Parent variety Mirikrak had the highest shoot weight. Pawnbuh exhibited either dominance or overdominance effect. For fresh and dry shoot weight, the gca estimates were significantly positive in Pawnbuh and negative in IR 28. On the basis of sca estimates, crosses IR 30 x Pawnbuh, Khonorullo x Pawnbuh, and IR 29 x Khonorullo were identified as the best combinations for effecting selection for tiller number, leaf and flag leaf area, and fresh and dry shoot weight.

Table 4. Estimates of sca effects of rice hybrids for different vegetative characters

Cross	Plant height	Tiller number	Leaf area	Flag leaf area	Fresh shoot wt.	Dry shoot wt.
IR 28 X IR 29	–4.49	–3.83**	–70.3	–107.3**	–11.49*	–7.52
IR 28 X IR 30	8.47**	0.49	–183.7	1.4	–10.74	–2.43
IR 28 X Khonorullo	0.36	2.52**	373.8	67.0*	12.04*	1.04
IR 28 X Mirikrak	11.73**	–2.43**	50.2	19.9	–37.53**	–8.23**
IR 28 X Pawnbuh	6.14*	2.95**	356.2	53.9	38.90**	11.49**
IR 28 X Ngoba	–5.20	2.02**	540.4	74.1*	–6.74	–1.12
IR 29 X IR 30	–2.04	2.44**	644.0*	24.4	–5.42	1.41
IR 29 X Khonorullo	14.24**	4.14**	1140.4**	170.8*	56.02**	17.26**
IR 29 X Mirikrak	7.72*	0.99	76.8	21.2	6.92	2.52
IR 29 X Pawnbuh	4.15	0.64	82.9	59.2	–3.20	1.77
IR 29 X Ngoba	5.52	–0.35	–320.0	22.2	–1.65	0.80
IR 30 X Khonorullo	–11.23**	–2.55**	–943.4**	–43.7	–16.88**	–3.37
IR 30 X Mirikrak	–0.10	0.71	–410.1	72.3	38.38**	14.77**
IR 30 X Pawnbuh	16.23**	3.02**	2239.0**	164.7**	37.08**	10.44**
IR 30 X Ngoba	-5.66	-0.70	-642.0*	-107.0**	-1.03	-5.33**
Khonorullo X Mirikrak	–5.27	1.20	806.1*	–66.4*	–2.07	–12.90**
Khonorullo X Pawnbuh	15.87**	1.93**	1645.8**	176.4**	38.01**	14.43**
Khonorullo X Ngoba	15.68**	–1.00	–90.0	–8.1	–6.09	1.10
Mirikrak X Pawnbuh	–3.81	1.50	10.9	–11.3	–2.35	–4.07*
Mirikrak X Ngoba	20.20**	0.58	620.4	191.4**	56.89**	10.56**
Pawnbuh X Ngoba	6.48*	–3.30**	91.4	–57.5	9.07	2.22
æSij	3.13	0.66	324.3	30.6	5.68	1.95

*, ** Significant at 5% and 1% levels, respectively.

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