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GENE EFFECTS IN FOUR METRIC TRAITS OF RICE BEAN

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ABSTRACT

Scaling tests and analysis of genic and interaction components of four metric traits were carried out in the progeny of three crosses involving four strains of rice bean (*Vigna umbellata* Thunb). Ohwi & Ohashi). Scaling tests A and C were significant for days to flower and green forage yield in two crosses. Additive gene effects were predominant for days to flower and plant height, whereas dominance effects were of major importance for number of branches per plant and green forage yield. Duplicate type genic interaction was noted for green forage yield. It is suggested that the significant dominance and interaction components can be exploited through the development of composite varieties in rice bean utilizing its very high rate of natural outcrossing.

Key words: Gene effects, scaling test, metric traits, rice bean.

Rice bean (*Vigna umbellata* (Thunb.) Ohwi & Ohashi) is a legume crop cultivated for grain as well as fodder. Some reports are available on the inheritance of a few qualitative and quantitative characters in this crop [1–6]. The gene effects from six–parameter analysis in four metric traits in rice bean are presented here.

MATERIALS AND METHODS

Four pure breeding strains, S_3, S_8, S_9 and S_{14} reported in [1] were used to raise the following crosses: $S_{14} \times S_3$, $S_{14} \times S_8$ and $S_{14} \times S_9$. Six populations (i.e., P_1, P_2, F_1, F_2, BC_1 and BC_2) of each cross were grown in two separate experiments, each in randomized block design with four replications in the University Farm at Gayeshpur, Nadia. A replication consisted of two rows each of the four parents, three F_1, six backcrosses involving these F_1, and five rows each of the three F_2 populations. Thus, each replication had total 41 rows of 2 m length. The row-to-row and plant-to-plant distances were 70 and 10 cm, respectively. The number of plants in each row was constant at 20 during the experiment. One border row of this crop was planted around the plot. The basal dose applied was 30 kg N, 60 kg P_2O_5 and 20 kg K_2O/ha. In one experiment, observations on plant height (cm) and number of branches per plant were taken from 10 random plants from each row on 65 days after sowing. The plants from each row of this experiment were harvested by cutting at soil level 66 days after sowing. Total 18 plants were

Table 2. Genetic and interaction components

Character & Cross	$\hat{D}$	$\hat{H}$	$(\hat{H}/\hat{D})1/2$	$\hat{m}$ (Genetic components)	$\hat{d}$ (Genetic components)	$\hat{h}$	$\hat{i}$ (Interaction components)	$\hat{j}$ (Interaction components)	$\hat{l}$ (Interaction components)	$\hat{h}/\hat{d}$	Nature of interaction
Days to flower											
S14 X S3	595.9	–412.2	–	76.2± 58.2	–71.5± 2.1**	33.6± 58.1	33.6± 58.1	14.7± 21.5	–81.7± 71.3	–0.5	–
S14 X S8	749.9	–781.0	–	–	–	–	–	–	–	–	–
S14 X S8	590.9	–429.6	–	97.1± 59.1	–86.8± 2.1**	5.0± 59.3	5.0± 59.3	18.2± 20.0	–46.8± 68.5	–0.1	–
No. of branches											
S14 X S3	0.3	6.5	4.4	–	–	–	–	–	–	–	–
S14 X S8	2.2	6.3	1.7	–	–	–	–	–	–	–	–
S14 X S9	1.4	3.8	1.7	–	–	–	–	–	–	–	–
Plant height											
S14 X S3	588.9	–339.5	–	–	–	–	–	–	–	–	–
S14 X S8	484.9	–261.9	–	–	–	–	–	–	–	–	–
S14 X S0	855.0	–319.9	–	–	–	–	–	–	–	–	–
Green forage yield											
S14 X S3	0.2	0.2	1.0	–0.8± 2.2	0.3± 0.2	10.5± 5.3*	2.6± 2.1	1.4± 1.2	–1.4± 2.1	35.0	Duplicate
S14 X S8	0.2	0.7	2.2	–	–	–	–	–	–	–	–
S14 X S9	0.03	0.6	4.9	–3.9± 2.4	0.1± 0.2	9.9± 3.9**	4.2± 2.3	5.8± 1.3**	–4.2± 3.2	99.0	Duplicate

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

harvested from each row and the green forage yield (in kg) was recorded immediately after the harvest.

From the second experiment, the day on which the first flower opened in a plant was recorded on 10 random plants from each row. Additive ($\hat{D}$) and dominance ($\hat{H}$) components were calculated from the variance of six generations [7].

The additive ($\hat{d}$) and dominance ($\hat{h}$) effects and the nonallelic interaction components ($\hat{i}$, $\hat{j}$ and $\hat{l}$) of generation means were estimated according to [8] wherever any one of the three scaling tests (A, B and C) was significant [7]. Heterosis was computed from $\bar{F}_1$–MP (MP = midparent $(P_1+P_2)/2$) for those crosses only.

RESULTS

The means of six generations (P_1, P_2, F_1, F_2, BC_1, BC_2) and the scaling tests (A, B and C) for four characters of each cross ($S_{14} \times S_3$, $S_{14} \times S_8$ and $S_{14} \times S_9$) are presented in Table 1, besides the estimates of heterosis for days to flower and green forage yield in the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$.

The estimates $\hat{D}$ and $\hat{H}$ for four characters of each cross are presented in Table 2. The estimates of genetic interaction components, additive ($\hat{d}$), dominance ($\hat{h}$), additive x additive ($\hat{i}$), additive x dominance ($\hat{j}$), and dominance x dominance ($\hat{l}$), derived from the six-parameter model for days to flower and green forage yield in the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$ are presented in Table 2, besides the nature of interaction for green forage yield.

DAYS TO FLOWER

Among the scaling tests (A, B and C), only the test A was significant at 1% level in the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$. Heterosis was negative for the cross $S_{14} \times S_3$ and positive for $S_{14} \times S_9$. The $\hat{H}$ component was negative in all three crosses and it was much lower than the $\hat{D}$ component in the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$. The $\hat{D}$ component was lower than $\hat{H}$ component in cross $S_{14} \times S_8$. The additive effect ($\hat{d}$) was the highest in cross $S_{14} \times S_9$ but it was slightly lower than the epistasis component ($\hat{l}$) in cross $S_{14} \times S_3$, though the former was significant at 1% level in both crosses. The average degree of dominance $\hat{h}/\hat{d}$ was less than unity in both these crosses.

NUMBER OF BRANCHES

Scaling tests A, B and C were not significant for the three crosses. The $\hat{H}$ component was higher than the $\hat{D}$ component for each cross. Average degree of dominance ($\hat{H}/\hat{D}$) was greater than unity for all the crosses, and was maximum in cross $S_{14} \times S_3$.

Table 1. Generation means amd scaling tests

Cross	Generation mean							Heterosis	Scaling test		
	$\bar{P}1$	$\bar{P}2$	MP	$\bar{F}1$	$\bar{BC}1$	$\bar{BC}2$	$\bar{F}2$	$\bar{F}$–M	A	B	C
Days to flower											
S14 X S3	74.0 ± 3.1	145.5 ± 3.0	109.8	104.4 ± 2.6	105.0 ± 7.3	133.5 ± 7.6	110.9 ± 4.3	–5.4	32.4 ± 1.2**	16.7 ± 15.6	14.5 ± 57.6
S14 X S8	71.7 ± 3.2	145.5 ± 3.0	108.6	102.7 ± 2.1	87.6 ± 8.5	121.6 ± 7.2	112.2 ± 13.7	–	0.8 ± 1.3	–5.0 ± 14.8	26.2 ± 55.1
S14 X S9	58.7 ± 3.0	145.5 ± 3.0	102.1	106.7 ± 2.1	97.7 ± 6.8	132.0 ± 0.1	113.6 ± 14.0	+4.6	30.0 ± 1.0**	11.8 ± 14.6	36.8 ± 56.3
No. of branches											
S14 X S3	4.7 ± 0.9	3.9 ± 0.6	4.3	5.7 ± 0.4	3.6 ± 1.4	3.9 ± 2.0	4.2 ± 1.5	–	–3.2 ± 3.0	–1.8 ± 3.0	3.2 ± 6.1
S14 X S8	4.1 ± 0.3	3.9 ± 0.6	4.0	5.5 ± 0.3	3.8 ± 1.5	4.0 ± 1.5	4.2 ± 1.7	–	–2.0 ± 3.1	–1.4 ± 3.0	–2.2 ± 6.8
S14 x S9	5.0 ± 0.4	3.9 ± 0.6	4.5	5.3 ± 0.3	4.7 ± 2.2	3.9 ± 1.2	4.5 ± 2.1	–	–0. ± 2.4	–1. ± 2.4	–1. ± 5.3
Plant height											
S14 x S3	103.7 ± 5.9	73.5 ± 4.7	88.6	84.5 ± 3.9	98.6 ± 1.3	90.6 ± 8.2	93.2 ± 15.3	–	9.0 ± 21.7	23.2 ± 17.6	26.6 ± 62.1
S14 x S8	76.6 ± 5.5	73.5 ± 4.7	75.1	80.3 ± 3.6	74.8 ± 9.0	76.7 ± 7.5	82.6 ± 14.1	–	–7.3 ± 20.9	–0.4 ± 16.1	19.7 ± 57.3
S14 x S9	38.9 ± 5.3	73.5 ± 4.7	56.2	86.7 ± 3.0	77.5 ± 1.8	80.8 ± 1.8	84.0 ± 19.2	–	29.4 ± 28.3	1.4 ± 22.3	50.2 ± 77.2
Green forage yield											
S14 x S3	1.8 ± 0.3	1.2 ± 0.2	1.5	3.0 ± 0.2	2.0 ± 0.4	1.9 ± 0.4	1.3 ± 0.4	+1.5	–0.8 ± 0.8	–0.4 ± 0.9	–3.8 ± 1.9*
S14 x S8	1.5 ± 0.1	1.2 ± 0.2	1.4	2.8 ± 0.2	2.1 ± 0.5	2.4 ± 0.5	1.3 ± 0.5	–	–0.1 ± 1.0	0.8 ± 1.1	–3.1 ± 2.2
S14 x S9	1.4 ± 0.2	1.2 ± 0.2	1.3	2.8 ± 0.3	2.2 ± 0.5	1.9 ± 0.4	1.0 ± 0.5	+1.5	0.5 ± 1.0	0.1 ± 0.9	–4.2 ± 1.9**

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

PLANT HEIGHT

None of the scaling tests was significant in the three crosses. Component $\hat{D}$ was higher than $\hat{H}$ component and the latter was negative in all the crosses.

GREEN FORAGE YIELD

Only scaling test C was significant for the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$. The $\hat{H}$ component was higher than $\hat{D}$ component for two crosses. Higher average degree of dominance, $(\hat{H}/\hat{D})^{1/2}$ was observed in the cross $S_{14} \times S_9$. The dominance effect $(\hat{h})$ was significant in the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$. The epistasis component for additive x dominance $(\hat{j})$ was significant in the cross $S_{14} \times S_9$ only. Average degree of dominance, $\hat{h}/\hat{d}$, was greater than unity for the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$. Duplicate type interaction was inferred in these two crosses.

DISCUSSION

The validity of the estimation of interaction components, $\hat{m}$, $\hat{d}$, $\hat{h}$, $\hat{i}$, $\hat{j}$ and $\hat{l}$, is based on the scaling tests A, B and C when any one of them is significant [9]. The scaling test A was significant for days to flower and test C for green forage yield in the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$ only. These tests indicated the existence of interaction components. For green forage yield in the crosses $S_{14} \times S_3$ and $S_{14} \times S_9$, the dominance component $\hat{h}$ was significant but opposite in sign to the component $\hat{l}$. Hence, the interaction was duplicate type in this case.

The considerable amount of dominance and interaction estimates for number of branches and green forage yield indicates that improvement for these two characters can be achieved through composite variety breeding. A recent report of very high rate of natural outcrossing in rice bean [10] has opened up the possibility of composite variety development in this crop.

The predominantly additive genetic component for days to flower and plant height in all the crosses can be improved upon through mass selection in this often cross pollinated species. Moreover, composite variety programme can also improve the performance of these two characters in the final population. So it is suggested that composite variety breeding should be initiated for improvement in rice bean.

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