Theoretical and Applied Genetics 41, 279—281 (1971)

Analysis of Diallel Cross in *Phaseolus aureus* Roxb.

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Summary. In a diallel cross of *Phaseolus aureus* involving five varieties, combining ability and gene action for grain yield, grains per pod and pods per plant were estimated. The study indicated that both general combining ability and specific combining ability effects were significant and important for all three traits. Partial dominance for grain yield and partial to over-dominance for grains per pod and pods per plant were observed. Dominant genes seem to govern the inheritance of all three characters. Combining ability, and graphical and component variance analyses indicated that the grain yield and two of its components are influenced by both additive and non-additive gene action.

Introduction

The aim of most plant breeding programmes is to increase the yield potential of the crop. This is fulfilled either by breeding lines resistant to one or many adversities or by improving the genetic potential of the plants. In *Phaseolus aureus* the latter approach has received considerable attention. In cross-pollinated and a few self-pollinated crops, the utilization of hybrid vigour in the F_1 generation has received maximum emphasis in the breeding programme. The production of hybrid varieties in many self-pollinated crops has not been economically feasible. In such crops, pure lines derived from hybrids have been utilized.

In general, considerable emphasis has been laid on identifying the pure lines for best combining ability and their F_1 crosses for best performing hybrids. Griffing (1956) has discussed a method utilizing diallel crosses for the precise measurement of general and specific combining ability. Information on the mode of inheritance should increase the effectiveness of selection. Graphical analysis, suggested by Hayman (1954), provides information on the nature of inheritance and gene action for quantitative traits. Another approach to this problem, by variance component analysis as suggested by Hayman (1954) and Jink (1954), furnishes information on the relative magnitude of additive, non-additive and environmental components of variance.

Information on combining ability and genetic parameters by diallel cross analysis is lacking in *Phaseolus aureus*. The results of a study of combining ability and inheritance for grain yield, grains per pod and pods per plant are reported here.

Material and Methods

A complete diallel set (ignoring reciprocals) involving five varieties, namely Hyb. 45 (M.P.), T 51 (U.P.), No. 54 (Punjab), NP 18 (Pusa, Bihar) and No. 305 (Punjab) of *Phaseolus aureus* was made at Punjab Agricultural University Experiment Station, Ludhiana, India, in 1967. These varieties were selected for high yield, variation in maturity, general agronomic desirability and divergence. Five parental lines and their 10 F_1 generations were grown during 1968, in a randomized block design with three replications. Rows and plants were spaced 90 cm and 30 cm apart respectively. One row each of the parents and F_1's were sown as a row, 3 metres long, accommodating 10 plants. Non-experimental material was sown all around the plots to avoid border effects. The observations were recorded on five randomly selected plants per entry of parents and F_1's from each replication for total grain yield per plant, grains per pod and pods per plant.

Statistical analysis was made on the mean of the five plants data per entry. Estimates of general and specific combining ability were made following the technique of Griffing (1956) for system 2 model I. Graphical analysis was carried out by the diallel cross technique given by Jinks (1954) and Hayman (1954). The technique given by Hayman (1954) was used for variance component analysis to estimate D, H_1, H_2, F, E, $\sqrt{H_1/D}$ u, and v.

Results

Combining Ability Analysis

The mean values of parental lines and their F_1 hybrids for all the characters are given in Table 1. The analysis of variance for general and specific combining ability indicated highly significant differences for all the traits, except for grain yield and seeds per pod where specific combining ability was significant at 5 per cent only (Table 2). When the variances of specific combining ability were compared with general combining ability variance, they were found to be non-significant.

The general combining ability estimates show that the parents, Hyb. 45 and No. 305, had high general combining ability for grain yield and pods per plant, as did No. 54 for seeds per pod (Table 3). The cross between Hyb. 45 × No. 305 had the highest values for specific combining abilities for grain yield and pods per plant, and Hyb. 45 × T 51 had the highest values for seeds per pod (Table 4).

Graphical Analysis

In Vr Wr graph (Figure 1 a) the slope of the regression line for grain yield differed greatly from expected

Table 1. *Mean values of five parental lines and their F_1 hybrids for grain yield per plant in g (X_1), number of grains per pod (X_2) and number of pods per plant (X_3)*

Parents	Variable	P_1	P_2	P_3	P_4	P_5
P_1 Hyb. 45	X_1	9.73	14.07	22.80	16.90	31.83
	X_2	9.47	10.77	9.60	10.00	10.00
	X_3	47.70	68.20	118.80	88.10	137.10
P_2 *T* 51	X_1		3.30	16.50	6.17	12.37
	X_2		8.10	9.83	9.40	9.02
	X_3		37.40	89.30	46.30	6.96
P_3 No. 54	X_1			13.43	12.70	16.17
	X_2			9.00	8.30	9.23
	X_3			83.70	78.00	85.10
P_4 No. 18	X_1				6.80	13.07
	X_2				9.23	9.37
	X_3				43.30	74.60
P_5 No. 305	X_1					12.53
	X_2					9.40
	X_3					71.70

S.E. $\pm$ (X_1) = 5.025 L.S.D. 5% (X_1) = 10.301
S.E. $\pm$ (X_2) = 0.571 L.S.D. 5% (X_2) = 1.171
S.E. $\pm$ (X_3) = 6.281 L.S.D. 5% (X_3) = 12.876

Table 2. *Analysis of variance for combining ability effects*

Source of variation	d.f.	Mean square of different characters		
		Grain yield	Grains per pod	Pods per plant
G.C.A.	4	72.80**	0.460*	1109.3**
S.C.A.	10	37.69*	0.420*	604.8**
Error	28	12.60	0.163	18.70

* Significant at P = 0.05
** Significant at P = 0.01

Table 3. *Estimates of general combining ability effects*

Parent	Estimated general combining ability effects of parent		
	Grain yield	Grains per pod	Pods per plant
Hyb. 45	3.10	0.437	7.52
T 51	−3.95	−0.161	−15.39
No. 54	1.67	−0.184	11.95
NP 18	−2.99	−0.117	−11.77
No. 305	2.17	0.024	7.69

S.E. $\pm$ (Gij) (X_1) = 1.20 L.S.D. at 5% (X_1) = 3.90
S.E. $\pm$ (Gij) (X_2) = 0.453 (X_2) = 0.043
S.E. $\pm$ (Gij) (X_3) = 1.46 (X_3) = 4.86

unit slope, suggesting genetic interaction. The line of regression cut the Wr-axis above the point of origin indicating partial dominance. The spread of array points along the regression line was wide showing that the parents were genetically diverse for grain yield. The regression line of Wr W′ graph (Figure 1 b) had a slope of $b = 0.0008 \pm 0.2500$ which did not differ from the expected slope (0.50) and indicated

Table 4. *Specific combining ability effects for grain yield (X_1), seeds per pod (X_2) and number of pods per plant (X_3)*

Parents	Variable	P_2	P_3	P_4	P_5
P_1 Hyb. 45	X_1	1.02	4.13	2.89	12.67
	X_2	1.12	−0.02	0.32	0.17
	X_3	0.08	24.34	16.35	45.88
P_2 *T* 51	X_1		4.89	−0.79	0.26
	X_2		0.80	0.21	− 0.21
	X_3		16.75	−2.53	1.31
P_3 No. 54	X_1			0.12	− 1.56
	X_2			−0.77	0.02
	X_3			1.82	−10.53
P_4 N.P. 18	X_1				0.00
	X_2				0.09
—	X_3				2.68

S.E. $\pm$ (Sij) (X_1) = 3.099 L.S.D. at 5% (X_1) = 5.64
S.E. $\pm$ (Sij) (X_2) = 0.031 (X_2) = 0.064
S.E. $\pm$ (Sij) (X_3) = 3.774 (X_3) = 6.87

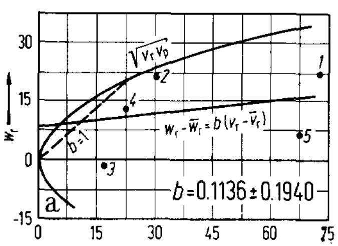

Fig. 1a. Vr Wr graph for grain yield per plant

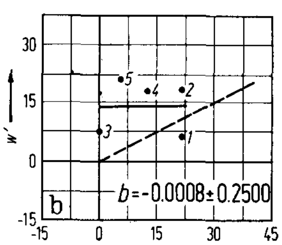

Fig. 1b. Wr W′ graph for grain yield per plant

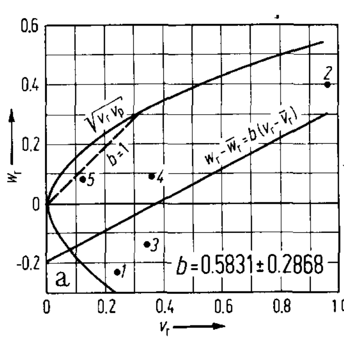

Fig. 2a. Vr Wr graph for number of seeds per pod

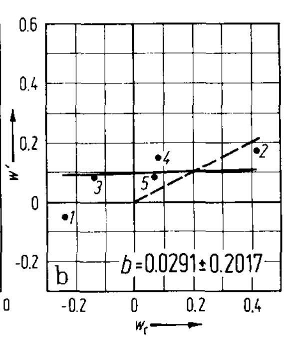

Fig. 2b. Wr W′ graph for number of seeds per pod

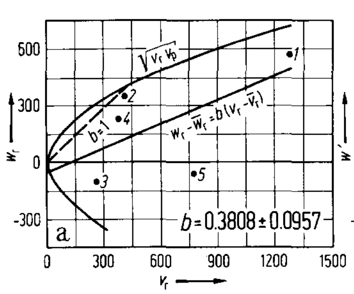

Fig. 3a. Vr Wr graph for number of pods

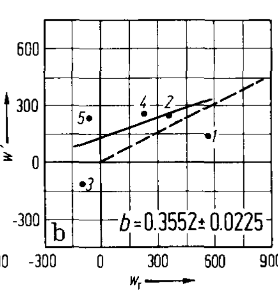

Fig. 3b. Wr W′ graph for number of pods

the absence of genic interaction. All other findings of the Vr Wr graph were supported by this graph.

The slope of the regression line in Vr Wr graph (Figure 2a) for seeds per pod differed significantly from expected unit slope indicating genic interaction. The regression line cut the Wr-axis above the point of origin showing partial dominance. Genetic diversity among the parents for seeds per pod was apparent from the spread of array points. The entire information gathered from the Vr Wr graph was confirmed by the Wr W′ graph (Figure 2b).

In the Vr Wr graph (Figure 3a), the slope of the regression line did not differ from the unit slope suggesting an additive type of gene action for pods per plant. The presence of over-dominance was obvious as the regression line intersected the Wr-axis below the point of origin. The wide spread of parents studied for seeds per pod was apparent from the wide spread of the array points. An additive type of gene action was confirmed from the Wr W′ graph as the regression slope did not differ significantly from the expected slope. Unlike the Vr Wr graph, the Wr W′ graph indicated partial dominance because the regression line intercepted the Wr-axis above the point of origin.

Component Analysis

The values for different components of variance are given in Table 5. The dominant component (H_1 or H_2) was much higher than the additive component (D) for all the traits, grain yield, seeds per pod and pods per plant. High negative F values for grain yield and pods per plant indicated an excess of recessive alleles over dominant alleles. Positive F values for seeds per pod indicated more dominant alleles than recessive alleles. The degree of dominance from $\sqrt{H_1/D}$ was greater than unit showing overdominance for all the traits. The preponderance of dominant (u) alleles compared with recessive (v) alleles was apparent.

Table 5. *Component of variance for grain yield, grains per pod and pods per plant*

Component	Grain yield	Grains per pod	Pods per plant
D	4.85	0.146	378.06
H_1	101.80	1.412	2091.44
H_2	90.68	0.978	1701.60
F	−31.16	0.26	−66.60
E	12.60	0.163	18.70
$\sqrt{H_1/D}$	4.58	3.11	2.35
u	0.74	0.78	0.70
v	0.26	0.22	0.30

Discussion

The findings indicate that both general combining ability and specific combining ability variances were important, although general combining ability variances had numerical superiority. Similarly, both general combining ability and specific ability variances were significant and of equal magnitude with regard to seeds per pod and pods per plant. Therefore, it can be concluded that both general and specific combining ability are important for these traits. It also suggests that both additive and non-additive types of gene action are involved for all the traits.

With regard to the importance of different parents in a breeding programme for the improvement of yield and two of its components, the results show that the parents No. 54, No. 305 and Hyb. 45 were the best because they had high general combining ability for yield and two of the components. The highest specific combining ability for yield and pods per plant was shown by a cross between Hyb. 45 × × No. 305, while the cross between Hyb. 45 × T 51 gave the highest specific combining ability. In general, crosses involving high × high general combiners gave high specific combining ability effects. None of the crosses between the low × low combiners gave high specific combining ability effects. It may be pointed out here that the values of the parents per se for two yield components were in close agreement with the one obtained with general combining ability estimates, while for yield there was some variation. But the per se performance of the crosses and estimates of specific combining ability effects were more closely related for yield and its component. Therefore the general practice of selecting parents on the basis of their values seems reasonably good.

The gene action expressed by the Vr Wr and Wr W′ graphs indicated partial dominance for grain yield and partial to overdominance for seeds per pod and pods per plant. The characters, grain yield, seeds per pod and pods per plant, were found to be conditioned by dominant genes.

Components of variance analysis indicated the preponderance of dominance components over additive components for all the traits. These findings are in agreement with graphical and combining analyses.

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Received July 2, 1970 / January 13. 1971

Communicated by M. S. Swaminathan

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