Diallel Analysis of Vegetable Soybean

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Introduction

Diallel studies furnish useful information regarding the selection of suitable parents for effective hybridization and at the same time elucidating the nature and magnitude of different types of gene action involved. In order to develop an efficient breeding plan leading to rapid improvement, such information on the development of desirable traits is lacking on vegetable soybean. With this aim, general and specific combining ability analyses of ten vegetable soybean for agronomic traits and nutritional values in a set of diallel and reciprocal crosses were studied

Materials and Methods

The materials for this study comprised of ten vegetable soybean genotypes chosen on the bases of agronomic traits, nutritional values, and panel taste test (Young et al.,1997; Mebrahtu et al., 1998). A complete diallel set of 90 crosses (including reciprocals) was made during the summer of 1997. The genetic materials comprising of 100 entries (including 10 parents, their 45 F_1 hybrids, and 45 F_1 reciprocals) were grown in 18 cm plastic-pots in the greenhouse, where F_1s from each cross were selfed to generate F_2s and the F_3 progenies were derived from the F_2. The genetic materials comprising of the ten parents, and their corresponding bulked F_2s and F_3s were planted in 1998 and 1999 growing seasons, respectively. Each genetic material was planted in RCBD with four replications in a single row plot (4.0 m x 0.75 m) and evaluated at green bean growth stages (R6 - R7; Fehr et al., 1971; Frank and Fehr 1981) by harvesting ten plants at random from each plot. Pods were removed by hand in the laboratory and the yield, pod dimensions, 100 pod weight, plant height, number of pods per plant were determined from 10 harvested plants. Pod samples that were taken at random from each plot were shelled by hand and the beans were freeze dried, ground and analyzed for total protein and total lipid. The agronomic and nutritional data were analyzed for general and specific combining ability and reciprocal differences by using Griffing (1956) Method 1, Model I.

Results

There were highly significant differences among the genotypes for all characters that lead to the combining ability analyses. The analyses of variances of F_2 and F_3 combining ability revealed that general combining ability (GCA) was highly significant. The GCA reflects the average performance of a genotype in hybrid combination and is primarily a measure of additive and/or digenetic variance. Highly significant mean squares for specific combining ability (SCA) were also observed

for both F_2 and F_3 progenies (Tables 1). The SCA is detected whenever a specific hybrid combination performances better (or worse) than would be expected based on the average performance of parental lines, and was a result of dominance and other non-additive gene actions. The significant GCA and SCA observed in this study indicated the importance of both additive and non-additive gene actions in the inheritance of the traits studied. However, higher magnitude of GCA variances indicated the more predominant role of additive effects for all characters under study (Table 1). It was also evident that the predominant role of additive variances by the subsequent increase of GCA magnitude in the F_3 generation

Table 1. The relative ratios of general to specific combining abilities variances in F_2 and F_3 for agronomic traits and nutritive values in vegetable soybean.

Parameters	GCA/SCA Variance¶	
	F_2	F_3
Plant Height (cm)	18.75	20.08
Hundred-Pod Weight (g)	7.27	15.39
Green Pod Yield (kg/plant)	1.47	2.09
Pods/Plant (number)	2.45	3.06
Pod Length (mm)	4.74	5.61
Pod Thickness (mm)	8.00	15.00
Pod Width (mm)	4.33	10.70
Protein (%)	4.07	6.70
Lipid (%)	1.23	3.91

¶ GCA = General Combining Ability, SCA = Specific Combining Ability

The performance of the parents was a good index of their general combining ability in the F_2 with correlation (*r*) values of 0.91**, 0.80, **, 0.74*, 0.87**, and 0.84** for plant height, hundred pod weight, green pod yield, total protein, and total lipid, respectively. A similar trend was also observed in F_3 generation with *r* values of 0.93**, 0.93** 0.82**, 0.82, and 0.92** for the above parameters.

The general combining ability for the F_2 and F_3 are presented in Table 2. Considering the plant height, PI 379621, PI 506852, and Late Giant had highly significant and positive GCE effects. On the other hand, V81-1603, Verde, PI 399055 and Tomahomare had low GCA effects in both generations, suggesting that these parents could be used in breeding program to improve plant stature. The genotypes that exhibited significant and positive GCA effects for hundred pod-weight (HPW) in the F_2 and F_3 generations were V81-1603, PI 399055, and Pella. These genotypes could be used as genetic source in improving pod size. Moreover, V81-1603 and PI 399055 had significant and positive GCA effects for green pod yield in the F_2 and Pella in F_3. The genotypes that consistently showed a positive GCA effect for green pod yield was Tomahomare.

Table 2. Parental mean and corresponding estimates of General Combining Ability (GCA) effects for 5 traits in vegetable soybean

Genotype	Plant Height (cm)		Hundred Pod Weight (g)		Green Pod Yield (kg/plant)		Protein (%)		Lipid (%)	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Kanrich	-0.74	-0.17	1.10	1.24	36.66	-132.83	-0.30	-0.04	-1.67	0.30
Pella	3.82	-0.48	5.27	9.92	-20.56	54.00	0.59	-0.50	0.84	1.22
Verde	-4.93	-6.87	-3.83	0.28	-113.05	-42.16	-0.96	-0.21	-0.80	-0.30
Tomahomare	-3.24	-2.18	-3.34	-8.91	58.25	61.74	-0.30	-1.12	0.23	-0.11
PI 506852	3.77	4.35	-8.81	-13.55	-4.38	76.21	-0.30	0.04	1.28	-0.71
PI 379621	6.89	12.55	-9.91	-15.87	-8.49	9.17	1.12	1.15	-0.37	-0.25
V81-1603	-6.64	-8.00	13.37	26.40	78.29	-0.93	0.05	0.22	0.24	-0.68
PI 399055	-4.26	-7.52	6.03	19.21	42.76	23.02	1.33	0.46	-0.98	0.35
VS95-50	-0.58	1.52	-1.71	-13.18	-39.02	-61.11	-0.64	-0.31	-0.12	-0.33
Late Giant	5.64	8.27	1.14	-5.56	-30.47	12.88	0.18	0.31	1.36	0.52
S.E ($g_i - g_j$) $\forall$	1.10	1.16	2.08	2.39	35.46	34.03	0.51	0.17	0.22	0.24

The protein concentration of the parents in F_2 ranged from 35.0 for Verde to 43.4% for PI 399055 with the mean of 39.5% and in F_3 the mean protein ranged from 36.2% for Pella to 40.5 % for PI 379621 with a mean of 38.6%. The genotypes with good combining ability for protein in the F_2 and F_3 were PIs 399055 and 379621 and had positive and significant GCA effects. Generally, the genotypes with high protein content tend to be good general combiners. Hence, the parents phenotypic mean could possibly serve as good indicators in predicting the performance of progenies. Conversely, parents with high protein tend to have low lipid contents and negative GCA effects. Therefore, a different breeding strategy should be designed to develop genotypes with desired oil or protein contents. Generally, the similarity in the estimates of combining ability in the F_2 and F_3 indicated that the good general combiners are also stable in their performance over generations.

Based on the F_2 specific combining ability effect for green pod yield high SCA effect were detected in crosses of Tomhomare x Kanrich, PI 379621 x Pella, and PI 399055 x Pella. The other crosses with significant positive SCA effects in the F_3 were Late Giant x VS95-50, PI 399055 x Tomhomare, PI 506852 x Kanrich, and V81-1603 x Verde. For hundred pod weight, the cross combinations namely Tomahomre x Verde, Pella x Kanrich, V95-50 x Verde, and Late Giant x Tomahomare (F_2) and VS95-50 x Tomahomare, PI 399055 x Verde, and V81-1603 x Pella (F_3) showed significant and desirable SCA effects. For protein, the crosses with desirable combinations in the F_2 were PI 506852 x Verde, V81-1603 x Pella, and PI 399055 x Pella and in F_3 PI 379621 x Pella, PI 399055 x Verde, and V81-1603 x Pella. The combination of V81-1603 and Pella showed a

consistent SCA effect in both F_2 and F_3 progenies.

In some reciprocal crosses desirable and significant effects for hundred pod weight, green pod yield, and protein were observed. The cross combinations that showed significant and positive reciprocal effects in both F_2 and F_3 were PI 379621 x Verde, Late Giant x Tomahomare, and VS95-50 x Kanrcih for hundred pod weight, green pod yield, and protein, respectively. Even though, significant non-additive variances are observed the focus must be to get to homozygosity as fast as possible while reserving as much selection pressure as possible for the later generations.

Conclusions

The high correlation values observed between the GCA effects with parental values indicated the estimates of GCA effects of individual parents are useful predictor for progeny performance.

From the F_2 and F_3 diallel analysis study, PI 399055 and PI 379621 could serve as potential parents for breeding program that focuses in improving protein content. For hundred pod weight improvement, V81-1603 would be an ideal parent and for green pod yield, Tomahomare is good general combiner.

Recognizing the importance of soybean as a powerful tool in quest for health, more research is needed to identify and develop superior genotypes that fit into special niche market

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