Estimation of Heterosis and Combining Ability in Azukibean under Highland Growing Conditions in Thailand†

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ABSTRACT

Four varieties of azukibean (Vigna angularis) were used in a diallel cross without reciprocals to study heterotic performance and combining ability for seed yield and yield components in F1 hybrids at two altitudes (700 m and 1,200 m above sea level) in northern Thailand during the August to December 2003 growing season. Heterotic effects and combining abilities differed between altitudes. F1 hybrids exhibited both negative and positive heterotic effects on seed yield per plant over their mid-parents and better parents which, averaged over the two test sites, were -0.6 to 31.8 percent and -10.7 to 20.5 percent, respectively. Analysis of data for component traits indicated the importance of both additive and non-additive gene effects for number of branches per plant, seed size and seed yield per plant. The only statistically significant interaction with test site involved specific combining ability for seed yield per plant.

Key words: Azukibean, Heterosis, General combining ability, Specific combining ability, Highland growing conditions

INTRODUCTION

Azukibean (*Vigna angularis* [Willd.] Ohwi and Ohashi) is a new legume crop which was introduced recently from Japan by Royal Project Foundation for farmers to grow on the highlands in northern Thailand. The crop has a very good potential for these areas since the climatic conditions, especially low temperature during the growing season, are similar to those of its place of origin. Research work on cultural practices of azukibean in highland areas was reported by Smutkupt et al., (2004), and on yield stability by Kunkaew et al., (2004), but genetic study of this crop is still quite scarce. As a preliminary breeding program of azukibean, this study is aimed to estimate the heterosis and combining ability of traits of this crop for obtaining the genetic information on the inheritance of traits, to serve as a guideline for improving the well-adapted varieties for highland areas in Thailand.

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MATERIALS AND METHODS

Four azukibean varieties: Kamuidainagon, Hondawase, Akatsukidainagon and Erimo were crossed in all possible combinations without reciprocals for developing of six F1 hybrid crosses, plus the parental lines. Two different altitudes of highland research stations, Pangda Royal Research Station (700 m above sea level, ASL) and Khunpae Royal Development Center (1,200 m ASL) were selected as the test sites. The parental lines and F1's were grown during August to December 2003 in a field in a randomized complete block design with three replicates. F1 crosses were sown along with their parental lines in two-row plots of 2.5 m long, with spacing of 25 and 50 cm within and between the rows respectively, with one plant per mound. At pod maturity, observations were recorded on five competitive plants, taken randomly in each plot, to collect data for plant height, number of branches per plant, number of pods per plant, 100-seed weight and seed yield per plant. Heterosis (H) and heterobeltiosis (Hb) for particular traits were calculated as percent increase or decrease over mid- and better-parent values, respectively. Significant levels of H and Hb were determined by *t*-tests as described by Xin et al., (2003). The combining ability analysis for each character was done according to Model I, Method 2 of Griffing (1956).

RESULTS AND DISCISSION

The calculated values of heterosis (H) and heterobetiosis (Hb), shown in Table 1, indicated that each type of heterosis could be of either positive or negative values and might or might not be significantly different ($p<0.05$) from zero. F1 hybrids exhibited positive and negative heterotic effects on seed yield per plant over their mid- and better parents. The values averaged over the two test sites were -0.6 to 31.8 percent and -10.7 to 20.5 percent respectively. Hybrid Kamuidainagon × Erimo gave the highest average positive mid-parent heterosis (31.8 percent) while hybrid Hondawase × Erimo gave the highest average positive heterobeltiosis (20.5 percent) for seed yield per plant. Among the yield component traits, the hybrid Kamuidainagon × Hondawase gave the highest average positive mid-parent heterosis for 100-seed weight (8.9 percent) and Kamuidainagon × Erimo did so for number of pods per plant (31.1 percent). Considering heterosis at the different altitudes, the different climatic conditions between the test sites evidently influenced the patterns of heterotic expression. For example, the F1 hybrid of Hondawase × Erimo exhibited the highest significant positive heterosis of seed yield per plant over its both better- and mid-parent values at Pangda whereas small negative values were obtained at Khunpae. Similar results were reported by Kunkaew et al., (2004).

Table 1. Observed heterosis over better- (Hb) and mid-parent (H) values for seed yield per plant and yield components in six F1 crosses at two different environments.

F1 crosses	Location	No. of pods per plant		100-seed weight		Seed yield per plant	
		% Hb	% H	% Hb	% H	% Hb	% H
Kamuidainagon × Hondawase	Pangda	-25.4**	-13.1	-9.9**	4.6	1.8	4.7
	Khunpae	-11.9	-1.0	-1.3	13.5**	26.4**	31.0**
	Mean	-19.3**	-7.4	-5.8**	8.9**	12.8	16.2
Kamuidainagon × Akatsukidainagon	Pangda	-15.1	2.4	-7.6**	0.7	4.2	15.7
	Khunpae	-4.4	9.2	-1.3	9.5**	9.4	13.3
	Mean	-9.3	6.7	-4.2**	5.4**	5.2	14.0
Kamuidainagon × Erimo	Pangda	24.2	35.2*	-12.8**	10.3**	21.7	40.6*
	Khunpae	19.2	22.9**	-15.0	6.3	11.9	17.0*
	Mean	27.0**	31.1**	-14.0**	8.2**	19.7**	31.8**
Hondawase × Akatsukidainagon	Pangda	-8.6	-4.7	-13.0**	-6.8**	-2.4	11.1
	Khunpae	-10.5*	-8.8	-6.1**	-2.2	-15.3**	-9.1
	Mean	-9.0*	-6.4	-9.6**	-4.5**	-10.7*	-0.6
Hondawase × Erimo	Pangda	-2.6	21.9	-6.2**	4.0**	45.5**	64.0**
	Khunpae	3.6	13.2*	-3.5	6.6**	-7.8	-6.9
	Mean	-0.3	17.6*	-4.9**	5.3**	20.5**	29.2**
Akatsuidainagon × Erimo	Pangda	-12.1	13.4	-8.3**	8.1**	-11.9	11.1
	Khunpae	9.4	21.7**	-7.2**	6.4**	12.0	21.1*
	Mean	-2.2	18.1*	-7.6**	7.4**	-2.9	15.0*

*, ** Significant at $p<0.05$ and <0.01 respectively.

The analysis of variance of combining ability indicated that both the general combining ability (g.c.a.) and specific combining ability (s.c.a.) effects were significant for all evaluated characters, except g.c.a. and s.c.a. effects for plant height and s.c.a. effects for number of pods per plant (Table 2). This indicated that both additive and non-additive gene effects were involved in the expression of these traits. The g.c.a. effects were more statistically evident than s.c.a. effects for all traits except seed yield per plant, indicating strong additive genetic effects in the inheritance of these traits. These results agree with the findings of Kunta et al., (1997) in soybean. Han et al., (1984) reported that seed yield per plant of azukibean was polygenically controlled with partial non-additive gene effects. In addition, variation of this economic trait was influenced greatly by environments. Hence, the interaction of specific combining ability effect and test site (s.c.a. × L) was statistically evident only for seed yield per plant.

Table 2. Analysis of variance for combining ability of seed yield per plant and yield components. All effects tested against pooled error.

Source	d.f.	Mean Squares				
		Plant height	No. of branches per plant	No. of pods per plant	100-seed weight	Seed yield per plant
Location (L)	1	240.96**	28.42**	654.06**	0.17	369.47**
Block(location)	4	9.49	0.54	67.52	0.86	83.12**
Entries	9	12.80	3.72**	124.21**	29.58**	45.07**
g.c.a.	3	24.20	7.18**	239.36**	83.66**	42.02*
s.c.a.	6	7.10	1.99*	71.13	2.54**	46.60**
Entries × L	9	5.27	1.31	28.77	0.59	33.26**
g.c.a × L	3	11.03	1.37	79.12	0.45	11.51
s.c.a × L	6	2.40	1.28	3.60	0.66	44.14**
Pooled error	36	9.35	0.79	38.91	0.72	11.88

g.c.a. = general combining ability ; s.c.a. = specific combining ability
*, ** significant at p<0.05 and p<0.01 respectively

The estimates for g.c.a effects indicated that the parental line Akatsukidainagon showed significant positive across-site g.c.a. and therefore performed as a good general combiner for all traits except 100-seed weight. Kamuidainagon, by contrast, showed significant positive across-site g.c.a. and was therefore a good general combiner for 100-seed weight (Table 3).

Table 3. Estimates of general combining ability (g.c.a.) effects of parental lines for seed yield per plant and some yield components at two different environments.

Parents	Location	Plant height	No. of branches per plant	No. of pods per plant	100-seed weight	Seed yield per plant
Kamuidainagon	Pangda	-0.42	-0.45*	-2.91	2.00**	0.17
	Khunpae	-0.71	-0.74**	-2.04*	2.05**	1.08
	Mean	-0.56	-0.60**	-2.47**	2.03**	0.45
Hondawase	Pangda	-0.34	0.25	1.82	-0.74**	-0.30
	Khunpae	-1.13*	0.04	0.16	-0.45*	-0.95
	Mean	-0.73	0.15	0.99	-0.60**	-0.62
Akatsukidainagon	Pangda	1.33	0.51**	4.65**	0.22	1.89*
	Khunpae	0.78	0.44*	1.68	0.07	0.68
	Mean	1.05*	0.47**	3.16**	0.15	1.29*
Erimo	Pangda	-0.57	-0.31	-3.56*	-1.48**	-1.42
	Khunpae	1.06	0.26	0.18	-1.68**	-0.81
	Mean	0.24	-0.02	-1.68	-1.58**	-1.12*

*, ** Significant at p<0.05 and p<0.01 respectively.

The estimated s.c.a. effects are presented in Table 4. Two hybrids, Kamuidainagon x Erimo and Hondawase x Erimo gave significant positive across-sites s.c.a. effects for seed yield per plant. Among the yield components, positive s.c.a. effects were pronounced in some crosses such as Kamuidainagon x Hondawase, followed by Akatsukidainagon × Erimo which gave significant positive across-site s.c.a. effects for 100-seed weight, while Kamuidainagon × Erimo did so for number of pods and number of branches per plant. Statistically significant s.c.a. effects were not identified for plant height in any hybrid cross. Similar results for g.c.a. and s.c.a. effects were reported in mungbean (Shah Khattak et al., 2002) and soybean (Kunta et al., 1997).

Table 4. Estimates of specific combining ability (s.c.a.) effects of the six F1 crosses for seed yield per plant and yield components at two different environments.

Crosses	Location	Plant height	No. of branches per plant	No. of pods per plant	100-seed weight	Seed yield per plant
Kamuidainagon × Hondawase	Pangda	-1.98	-1.03**	-3.93	0.52*	-1.16
	Khunpae	-0.45	-0.78*	-1.34	1.20**	3.59**
	Mean	-1.22	-0.91**	-2.64	0.86**	1.22
Kamuidainagon × Akatsukidianagon	Pangda	1.08	0.15	1.64	-0.29	2.77
	Khunpae	0.06	-0.41	0.70	0.48	0.49
	Meam	0.57	-0.13	1.17	0.09	1.63
Kamuidainagon × Erimo	Pangda	1.11	0.80**	4.98	0.88**	3.30*
	Khunpae	0.67	0.53	3.52*	-0.03	1.42
	Mean	0.89	0.66**	4.25*	0.42	2.36*
Hondawase × Akatsukidainagon	Pangda	-0.26	0.82**	-1.52	-0.75**	-0.49
	Khumpae	-1.76	-0.43	-2.63	-0.57	-1.83
	Mean	-1.01	0.20	-2.08	-0.66**	-1.16
Hondawase × Erimo	Pangda	0.86	0.66*	3.05	-0.10	8.46**
	Khumpae	-0.44	-0.06	2.06	-0.04	-1.67
	Mean	0.21	0.30	2.55	-0.07	3.39**
Akasukidainagon × Erimo	Pangda	0.83	-0.36	1.99	0.76**	0.11
	Khumpae	1.30	0.95*	3.44*	0.57	2.31*
	Mean	1.07	0.30	2.71	0.66**	1.21

*, ** Significant at $p<0.05$ and $p<0.01$ respectively.

CONCLUSION

Results of this heterosis and combining ability study in four parental lines of azukibean, which were grown under two highland conditions, suggest that these findings will provide a useful tool for selection of desirable parents and knowing the nature and magnitudes of gene action for different traits for furthering azukibean breeding in Thailand.

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