Combining Ability Analysis of Yield and Yield Components in Azukibean under Highland Conditions of Northern Thailand

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ABSTRACT

Four varieties of azukibean (Vigna angularis) were manipulated in a half-diallel mating design to analyse and estimate combining ability for seed yield and yield components in F1 hybrid crosses at three different altitudes of highland area (1,300 m, 1,200 m and 700 m above sea level) in the north of Thailand during August to December 2005 growing season. Significant across-site effect on general combining ability and its interaction with location effect were statistically evident for yield components such as 100-seed weight and number of pods per plant, indicating that the additive genetic effects were important to the inheritance of these traits and the expression of additive genes was influenced greatly by environments. In addition, specific combining ability effect was statistically evident for seed yield per plant, number of seeds per pod and number of pods per plant, suggesting that non-additive gene effects played the significant roles in the inheritance of these traits but the expression of non-additive genes was slightly influenced by the environments.

Key words : Azukibean, DIALLEL-SAS program, General combining ability (g.c.a.), Specific combining ability (s.c.a.)

INTRODUCTION

The Royal Project Foundation introduced one famous azukibean (*Vigna angularis* [Willd] Ohwi and Ohashi) variety named "Erimo" from Japan for farmers to grow as a cash crop on the highland area in the northern part of Thailand since 1997. It has been reported that this promising azukibean variety is able to grow commercially under highland growing conditions but variations of grain yields which ranged from lowly- to highly-acceptable level were always obtained by the farmers. This unstable yield performance could probably be due to its narrow genetic base that resulted in expressing adaptive traits of growth and development within a specific range of highland environments. These observations were supported by yield trial results as reported by Julsrigival et al., (2004) and yield stability evaluation by Kunkaew et al., (2004). In order to develop a wider genetic base and create better adaptability for azukibean varieties for highland growing area in Thailand, analysis of combining ability of grain yield and yield components was the purpose of this study in order to serve as a guide line for azukibean varietal improvement program in the future.

MATERIALS AND METHODS

Half-diallel mating design was manipulated from four azukibean varieties, Kamuidainagon (g1), Hondawase (g2), Akatsukidainagon (g3) and Erimo (g4) to develop all possible six F1 hybrid crosses. Three highland research stations with different altitudes, viz., Inthanon Royal Research Station (1,300 m above sea level, ASL), Khunpae Royal Development Center (1,200 m ASL) and Pangda Royal Research Station (700 m ASL) were selected as the test sites. The parental lines and their six F1 hybrid crosses were grown during August to December 2005, in a randomized complete block design with four replications. F1 hybrid crosses were planted along with their respective parental lines in two-row plots of 3.0 m long, with spacing of 20 and 50 cm within and between the rows, respectively, with one plant per mound. At pod maturity, observations were made on five competitive plants, taken randomly in each plot, to collect data for number of pods per plant, number of seeds per pod, 100-seed weight and seed yield per plant. DIALLEL-SAS program developed by Zhang and Kang (2003) was used for analyzing diallel-cross data. The general combining ability (g.c.a.) and specific combining ability (s.c.a.) variance components and estimation of combining ability effects on each trait was done according to Model 1, Method 2 of Griffing (1956).

RESULTS AND DISCUSSION

Analysis of variance for diallel cross of azukibean parents over the three test sites is presented in Table 1. Results showed that significant differences were found among the locations (L) and among the entries (parents and offsprings) for number of pods per plant, number of seeds per pod, 100-seed weight and seed yield per plant. These results indicated that environmental conditions, especially temperature and moisture factors which varied from location to location, influenced the expression of yield and yield components of azukibean parents and their progenies.

Interaction of entries with location (Entries x L) was found to be significant for the number of seeds per pod and 100-seed weight, indicating that parents and their progenies were susceptible to environmental conditions as far as these two yield components were concerned while seed yield per plant and number of pods per plant showed higher stabilities since the interaction between entries x L of these two traits was not found. These results agreed with those of Yoopum and Julsrigival (2001), Julsrigival et al., (2004) and Kunkaew et al., (2004) who reported that some agronomic characters of azukibean genotypes such as plant height, number of branches per plant and so on were rather stable while seed yield and seed size were unstable when planted under highland conditions.

Table 1. Combined analysis of variance for seed yield per plant and yield components in a diallel cross of azukibean grown under three highland locations in 2005 growing season in the northern Thailand.

Sources	df	Number of pods per plant			Number of seeds per pod		
		MS	F-value	Pr>F	MS	F-value	Pr>F
Location (L)	2	361.42	8.72	0.0004	9.35	52.07	<.0001
Block(Location)	9	59.81	1.44	0.1838	0.17	1.47	0.1742
Entries	9	345.44	8.34	<.0001	4.39	38.57	<.0001
Entries x L	18	24.76	0.60	0.8915	0.34	2.95	0.0005
g.c.a.	3	222.84	5.38	0.0020	12.44	109.27	<.0001
s.c.a.	6	406.73	9.81	<.0001	0.37	3.21	0.0070
g.c.a. x L	6	14.27	0.34	0.9137	0.71	6.24	<.0001
s.c.a. x L	12	30.00	0.72	0.7279	0.15	1.31	0.2292
Error	81	41.44			0.11		

Table 1. (continue)

Sources	df	100-seed weight			Seed yield per plant		
		MS	F-value	Pr>F	MS	F-value	Pr>F
Location (L)	2	126.53	287.01	<.0001	533.32	19.63	<.0001
Block(Location)	9	1.27	2.89	0.0052	24.18	0.89	0.5381
Entries	9	54.36	123.31	<.0001	208.88	7.69	<.0001
Entries x L	18	1.56	3.54	<.0001	21.61	0.80	0.6999
g.c.a.	3	162.41	368.40	<.0001	34.71	1.28	0.2878
s.c.a.	6	0.34	0.77	0.5990	295.96	10.89	<.0001
g.c.a. x L	6	2.95	6.69	<.0001	18.39	0.68	0.6662
s.c.a. x L	12	0.86	1.96	0.0389	23.22	0.85	0.5996
Error	81	0.44			27.18		

Analysis of variance of combining ability indicated that effects of general combining ability (g.c.a.) were found to be significant for number of pods per plant, number of seeds per pod and 100-seed weight. The interaction of g.c.a. effects and location (g.c.a. x L) was statistically evident only for two traits, i.e., number of seeds per pod and 100-seed weight. The significant across-site g.c.a. effects and g.c.a. x L were found among these traits which revealed that additive genetic effects were important in the inheritance of these traits and the action of additive genes was influenced by the environmental variation. These results were supported by the work of Han et al., (1984) and Kunkaew et al., (2006) who reported that seed yield and some of yield components of azukibean were polygenetically controlled with additive gene effects. In addition, variation of these economic traits was influenced greatly by environments. Hence, interaction of g.c.a. effects with location of these evaluated traits was statistically evident.

For specific combining ability (s.c.a.) analysis, significant effects were found for most traits except 100-seed weight, indicating that the significant role of non-additive effects was involved in the inheritance of these traits and the action of non-additive genes was slightly influenced by the environments since the interaction of s.c.a. effects with location was not observed.

Estimation of combining ability effects among the azukibean parents is presented in Table 2. Results showed that Kamuidainagon (g1) and Akatsukidainagon (g3) parents gave significant positive across-site g.c.a. effects for 100-seed weight, indicating that these two parents were good combiners for inheriting of large seed-size trait to their progenies since both parents possessed large seeds. As well, Erimo parent (g4) showed significant positive across-site effects for number of seeds per pod and performed as a good combiner of this trait because the pod of this parent was quite long and contained more seeds per pod than the other parents.

The estimated specific combining ability effects revealed that there was only one hybrid of Kamuidainagon x Hondawase (s12) which gave significant positive across-site s.c.a. effects for number of seeds per pod and seed yield per plant. From this study of combining ability effects, it should be noted that significant positive g.c.a. effects were not found in azukibean parents for almost agronomic traits. As well, positive s.c.a. effects were not statistically evident for seed yield per plant and yield components in other hybrid crosses. These similarities, i.e., g.c.a. effects of parents and s.c.a. effects of hybrid crosses for some evaluated traits may be probably due to slight difference in agronomic traits of parental germplasms used. Similar results of such study were reported and discussed in peanut by Jogloy et al. (1999) and Kesmala et al., (2003). However, the authors decided to use DIALLEL-SAS program to analyse diallel-cross data for the study since this program has been extensively used in crops such as maize (*Zea may* L.), wheat (*Triticum aestivum* L.), rapeseed (*Brassica napus* L.) and so on (Zhang et al., 2005). Thus, this program is considered as an effective method in analyzing and interpreting diallel-cross data for researchers, especially for fixed model of Griffingís diallel method and experiments which are conducted in a number of environments. So, genetic information, both general combining ability and specific combining ability which were estimated and analyzed from this study should be reasonably interpreted and reported.

CONCLUSION

Results of combining ability analysis study of yield and yield components in azukibean parents which was conducted under three different highland environments suggest that these findings will provide to plant breeders useful genetic information such as general combining ability and specific combining ability and help them advise appropriate breeding and selection strategies for azukibean varietal improvement in Thailand.

Table 2. Estimate of general (g_i) and specific (s_{ij}) combining ability effects for seed yield per plant and yield components of azukibean averaged across three highland locations in 2005 growing season in the northern Thailand.

Parameters	Number of pods per plant				Number of seeds per pod			
	Estimates	S.E.	t-value	Pr>ltl	Estimates	S.E.	t-value	Pr>ltl
g1	-2.61	0.66	-3.97	0.0002	0.02	0.03	0.51	0.6142
g2	1.25	0.66	1.90	0.0608	-0.30	0.03	-8.84	<.0001
g3	0.72	0.66	1.09	0.2793	-0.29	0.03	-8.56	<.0001
g4	0.64	0.66	0.98	0.3309	0.58	0.03	16.89	<.0001
s11	-4.23	1.18	-3.60	0.0006	-0.25	0.06	-4.01	0.0001
s12	2.69	1.59	1.69	0.0954	0.4	0.08	2.87	0.0053
s13	0.08	1.59	0.05	0.9618	0.12	0.08	1.49	0.1392
s14	1.47	1.44	1.02	0.3114	-0.12	0.08	-1.55	0.1260
s22	-4.92	1.18	-4.19	<.0001	-0.14	0.06	-2.34	0.0218
s23	0.71	1.59	0.45	0.6650	0.03	0.08	0.36	0.7226
s24	1.52	1.44	1.06	0.2939	-0.12	0.08	-1.65	0.1026
s33	-2.19	1.18	-1.87	0.0655	-0.07	0.06	-1.17	0.2446
s34	1.40	1.44	0.98	0.3322	-0.08	0.05	-1.09	0.2799
s44	-4.39	2.88	-4.53	0.1311	0.32	0.15	2.14	0.0352

Table 2. (continue)

Parameters	100-seed weight				Seed yield per plant			
	Estimates	S.E.	t-value	Pr>ltl	Estimates	S.E.	t-value	Pr>ltl
g1	1.92	0.07	28.40	<.0001	0.04	0.53	0.08	0.9367
g2	-0.65	0.07	-9.53	<.0001	-0.58	0.53	-1.10	0.2752
g3	0.32	0.07	4.68	<.0001	-0.42	0.53	-0.79	0.4319
g4	-1.60	0.07	-23.55	<.0001	0.96	0.53	1.81	0.0742
s11	-0.06	0.12	-0.47	0.6391	-4.64	0.95	-4.88	<.0001
s12	0.13	0.16	0.80	0.4286	3.14	1.29	2.44	0.0170
s13	-0.15	0.16	-0.89	0.3784	0.61	1.29	0.47	0.6374
s14	0.07	0.15	0.48	0.6297	0.89	1.17	0.76	0.4465
s22	-0.10	0.12	-0.85	0.3960	-3.83	0.95	-4.02	0.0001
s23	-0.12	0.16	-0.71	0.4815	-0.28	1.29	-0.21	0.8310
s24	0.09	0.15	0.60	0.5508	0.96	1.17	0.82	0.4124
s33	0.10	0.12	0.84	0.4021	-1.36	0.95	-1.43	0.1561
s34	0.16	0.15	1.07	0.2863	1.03	1.17	0.88	0.3801
s44	-0.32	0.30	-1.08	0.2841	-2.88	2.33	-1.24	0.2201

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