Development of High Yield and Nutritious Mungbean Lines (*Vigna radiata* L. Wilczek) using Heterosis and Combining Ability Analysis

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Abstract

Genetic information concerning combining ability and heterosis give some clue for choosing the most suitable donors for hybridization. Thus, the examination has embraced the nature and extent of hereditary effects overseeing yield component behavior and general and specific combining abilities of mungbean utilizing the diallel cross method. Fifteen crosses originated from a half diallel method through six different mungbean parents for heterosis and combining ability investigation. The investigation was conducted at Pulses Research Center, BARI, Ishurdi, Pabna, in a randomized block design with three replications. Results showed highly significant variations within parents and F_1 segregates, and demonstrated a wide genetic variability for the studied characters. Thus, the chance of hereditary improvement utilizing genetic pools of mungbean is available. The mean square of general combining ability (GCA) and specific combining ability (SCA) were significant for all the characters, except mean square due to (SCA) for days to flowering, days to maturity and pod length showing significant role of both additive and main components in the inheritance of the studied characters. Higher effect of SCA than GCA was observed for plant height and seeds per pod brought up to be the preponderance of non-additive gene effects in the statement of these characters. Based on *per se* performance and GCA of the parents, BARI Mung-1, PS-7 and BMXK1-14004 were seen as the great general combiners for yield per plant. In context of SCA, five hybrids *viz.* BMXK1-14004 ×Sonali mung, BMXK1-14004 × PS-7, BMXK1-14004 × BINA Mung-8, Sukumar× PS-7 and BARI Mung-1 × BINA Mung-8 were perceived as promising. The most significant heterosis to the degree of 26.09% over standard variety and 20.20% over better parent for seed yield per plant were observed in the cross BMXK1-14004 × Sonali mung and BMXK1-14004 × PS-7 respectively which showed high heterosis rate for yield and yield contributing traits. These parents and crosses could be used for the further breeding program for improvement of the yield and genetic components of mungbean.

Introduction

❖ Legumes contribute significantly to providing nutritionally balanced food for the vegetarian population in Central Asia and India, as well as in Bangladesh.

❖Mungbean (*Vigna radiata* L.) is the main source of digestible proteins which helps to prevent many diseases by create antibody and antioxidant in human body such as coviq19, cancer and diabetis by releasing essential amino acid. Mungbean will play a role in eliminating malnutrition in poor people by ensuring nutritious-rich safe foods.

❖The extent of heterosis provides a guide for the selection of the desired parents based on genetic information (Sorajjapinun et al., 2012). Combination ability determined through diallel analysis is useful to assess parental cutting ability and the nature and magnitude of the different types of gene actions involved (Viraj, et al., 2020). The present study was undertaken to estimate the heterosis, combining ability effects for yield and its components traits in mungbean.

Materials and Methods

❖The experiment was conducted at Pulses Research Center of Bangladesh Agricultural Research Institute (BARI), Ishurdi, situated at 24.07° north latitude and 89.03° east longitude having an altitude of 11.58 meters above mean sea level. The plant materials comprised of six lines: 4 local lines *viz.* BMXK1-14004, BARI Mung-1, BINA Mung-8 and Sonali Mung, and 2 exotic lines *viz.* Sukumar and PS-7.

❖The crosses were attempted at green house during summer, 2015 in half diallel fashion (excluding reciprocals) to get all possible combinations (complete of 15 F_1s crosses). The seeds of 15 crosses were deliver through hand emasculation and hand pollination (Fig. 1).

❖The 15 F_1 crosses alongside their six parents established 21 lines were grown in a randomized block design with three replications in single-row plots of 4 m length at 30 x 10 cm spacing during developing periods of 2016 at PRC research field, BARI, Ishurdi, Pabna.

❖The data on ten randomly selected competitive plants in 6 parents and 15 F_1s per treatment per replication were recorded for seven quantitative traits. *viz.*, days to 50% flowering (DF), days to maturity(DM), plant height (cm), pods per plant, pod length, seeds per pod and seed yield per plant (g) .

Fig. 1: Pictorial views of experiment: A:- Emasculation, B:- Pod setting and C:- Experiment field preview at PRC in 2015

Materials and Methods (Cont.)

❖The combining ability analysis was conducted according to Griffing,s (1956) method 2 (Parents and one set of F1s without reciprocals) and Model-I (fixed effects) using statistical package PBTools 1.2. 2014 version utilizing R packages.

Fig. 2: Field trail of crossing materials with parents. A:- Experimentation field and B:- Close picture of crossing line with field.

Results

Analysis of variance for combining ability

The analysis of variance showed highly significant variations among the parents and off spring for all the studied characters, showing significant genetic variability present in the materials (Table 1).

Table 1. Analysis of variance for combining ability of different yield related traits in mungbean

Source of variance	d.f.	Mean square						
		DF	DM	Plant height	Pods plant^{-1}	Pod length	Seeds pod^{-1}	Yield plant^{-1}
Replications	2	3.45	5.54	0.25	2.49	0.03	2.78	0.03
Genotypes	20	51.78**	44.23**	248.19**	265.22**	2.74**	256.73**	2.66**
Parents	5	29.12**	66.45**	301.60**	73.81**	5.65**	80.89**	5.29**
Crosses	14	65.67**	38.43**	102.88**	346.93**	1.89**	248.05**	1.82**
Error	40	24.54**	24.23**	1.58	3.39	0.51	5.58	0.22
GCA^{+}	5	14.00**	14.43**	72.28**	109.02**	1.41*	40.06**	1.45*
SCA^{++}	15	5.67	10.22	85.22**	81.26**	0.57	100.42**	0.52**
Error	40	0.87	0.76	0.50	1.11	0.15	1.65	0.07
GCA/SCA		2.47	1.41	0.85	1.34	2.47	0.40	2.79

df= Degrees of freedom, GCA= General combining ability and SCA= Specific combining ability,
*, ** Significant at 5% and 1% level of probability, respectively

General Combining Ability Effects (GCA)

The parent P_1 (BMXK1-14004) indicated highly significant and positive effect of GCA effect for the number of pods plant^{-1}and plant height, similarly P_5 (PS-7) and P_2 (BARI Mung-1) for pod length, P_4 (Sukumar), P_5 (PS-7) and P_2 (BARI Mung-1) for seed yield plant^{-1}, suggestive that these varieties as a great combiner for these attributes (Table 2).

Table 2. Estimates of general combining ability effects of the parents for yield and different characters

Parents	Characters						
	DF	DM	Plant height	Pods plant^{-1}	Pod length	Seeds pod^{-1}	Yield plant^{-1}
P_1	-0.37	-0.03	2.86**	6.11**	-0.23	-0.24	0.34*
P_2	-1.28**	1.54**	-2.92**	-1.49**	0.35*	0.51	0.36*
P_3	-0.55	-0.86	-2.25**	1.68**	0.09	0.67	-0.05
P_4	2.54**	2.24**	3.97**	0.75	-0.50*	3.68**	0.50**
P_5	-0.27	1.22*	-2.61**	-3.21**	0.59**	-2.21**	0.46**
P_6	-0.26	-0.81	0.93**	-3.86**	-0.29	-2.43**	-0.51**
SE Gi	0.27	0.51	0.23	0.34	0.13	0.41	0.08
SE Gi-Gj	0.42	0.69	0.35	0.53	0.20	0.64	0.13

* Significant at 0.05 levels of probability, & ** Significant at 0.01 levels of probability

Specific Combining Ability effect (SCA)

Among fifteen crosses, P_1×P_6, P_3×P_6 and P_1×P_3 gave a highly significant and negative assessment of SCA effects for days to maturity and plant height (Table 3). The crosses P_2×P_3, P_3×P_6, P_1×P_5, P_2×P_4 and P_2×P_5 for the number of seeds pods^{-1} have highly significant and positive SCA effects. Five crosses (P_1×P_6, P_1×P_5, P_4×P_5, P_1×P_3 and P_2×P_3) out of fifteen crosses were having significantly best SCA effect for seed yield plant^{-1}.

Heterosis

The cross P_4 × P_5 (Sukumar × PS-7) shows high positive heterotic effects for pod length and grain yield plant^{-1}and high negative heterotic effects for plant height may be exploited for the above characteristics to grow high yielding mungbean cultivars (Table 4).

Results (Cont.)

Table 3. SCA effects of the different 15 crosses for yield related traits in mungbean

Crosses	Characters						
	DF	DM	Plant height	Pods plant^{-1}	Pod length	Seeds pod^{-1}	Yield plant^{-1}
P_1×P_2	-0.75	0.85	2.74**	0.45	0.04	-16.45**	-0.01
P_1×P_3	2.83**	2.01	-2.57**	-10.64**	0.54	-2.95**	0.77*
P_1×P_4	-0.09	-0.83	0.95	6.37**	0.72	0.05	0.42
P_1×P_5	0.26	-0.39	4.03**	24.31**	-1.42	5.93**	0.82*
P_1×P_6	2.22**	-3.08*	-3.27**	-6.10**	-1.11**	2.83	0.84*
P_2×P_3	1.38	3.35*	7.58**	9.35**	-1.14*	6.30**	0.68*
P_2×P_4	2.25**	6.68***	0.38	2.65*	0.53*	4.63**	-0.93**
P_2×P_5	0.08	5.23**	9.74*	-6.53**	0.28	3.18*	-0.05
P_2×P_6	2.68**	2.04	1.59	2.28	0.41	2.74	-0.74*
P_3×P_4	3.02**	-0.08	8.08**	-0.20	0.83	-11.20**	-0.37
P_3×P_5	-0.64	-0.56	0.23	-5.64**	-0.26	-20.66**	-0.85*
P_3×P_6	0.44	-0.86	-3.23**	8.02**	0.01	6.24**	-0.71*
P_4×P_5	4.36***	2.48	17.16**	-3.24*	-0.26	-2.33	0.78**
P_4×P_6	4.36***	5.29***	0.66	-0.76	-0.37	-4.76**	0.19
P_5×P_6	-0.34	-0.71	5.85**	-10.06**	0.56	-11.22**	-0.45
SE Sij	0.74	1.29	0.63	0.93	0.35	1.14	0.23
SE Sij-Sik	1.11	1.93	0.94	1.39	0.52	1.70	0.35
SE Sij-Skl	1.03	1.79	0.87	1.29	0.48	1.57	0.32

Table 4. Heterosis values (%) over mid parent and better parent of fifteen mungbean crosses

Crosses	DM		Plant height		Pods plant^{-1}		Pod length		Yield plant^{-1}	
	MP (%)	BP (%)	MP (%)	BP (%)	MP (%)	BP (%)	MP (%)	BP (%)	MP (%)	BP (%)
P_1×P_2	11.97**	11.19**	-4.12**	-10.91**	23.02**	-2.92**	2.56*	-5.88*	2.99**	-3.37**
P_1×P_3	12.86**	12.06**	-18.77**	-29.86**	-15.35**	-21.78**	6.05**	-0.49 NS	5.77**	5.77**
P_1×P_4	10.07**	8.51**	-8.06**	-28.42**	26.48**	25.00**	10.98**	3.94**	4.70**	12.82**
P_1×P_5	-3.52**	-4.20**	9.08**	6.94**	47.36**	5.99**	11.00**	-0.22 NS	11.86**	20.20**
P_1×P_6	-5.37**	-10.19**	4.36**	-2.64*	24.14**	5.99**	13.16**	6.17**	26.09**	11.54**
P_2×P_3	-4.26**	-5.59**	-23.71**	-28.04**	54.76**	34.48**	12.05**	9.41**	6.59**	-3.37**
P_2×P_4	9.29**	6.99**	-16.37**	-25.85**	15.33**	-5.39**	12.93**	-2.35*	-13.75**	-22.47**
P_2×P_5	6.99**	6.99**	-13.50**	-35.90**	3.02**	-12.38**	6.32**	3.93**	-8.51**	-13.13**
P_2×P_6	1.33 NS	-3.18**	6.76**	1.89 NS	15.13**	8.47**	17.81**	1.18 NS	-9.40**	-24.16**
P_3×P_4	10.87**	10.07**	-11.00**	-20.48**	1.76 NS	-4.94**	16.08**	2.47*	-9.40**	-13.46**
P_3×P_5	8.51**	6.99**	-31.00**	-8.60**	13.64**	-13.79**	-2.35*	-6.74**	-18.08**	-26.77**
P_3×P_6	6.08**	-1.27 NS	-9.19**	-74.59**	32.33**	21.38**	-4.23**	-16.05**	-8.70**	-19.23**
P_4×P_5	-5.00**	-6.99**	15.00**	37.40**	5.37**	-23.65**	16.85**	16.85**	8.24**	-7.07**
P_4×P_6	1.36 NS	-5.10**	20.27**	15.41**	-10.59**	-22.90**	8.94**	8.06**	-0.76 NS	-8.45**
P_5×P_6	6.00**	1.27 NS	17.11**	117.11**	-38.78**	-50.41**	36.07**	38.07**	-14.09**	-31.01**

MP-Mid parents and BP-Better parents

Conclusions

❑**Based on combining ability analysis, the most promising parents P_2 (BARI Mung-1) and P_5 (PS-7) for yield plant^{-1}, pod length and plant height; P_4 (Sukumar) for seeds pod^{-1}, and others desirable traits such as pods plant^{-1}andyield plant^{-1} for P_1 (BMXK1-14004).**

❑ **The crosses *viz.*, P_1×P_6, P_1×P_5, P_1×P_3, P_4×P_5 and P_2×P_3 were distinguished as best specific cross combinations for the majority of the yield attributes. The crosses P1×P5 (BMXK1-14004 × PS-7), P_1×P_6 (BMXK1-14004 ×Sonali mung), P_1×P_4 (BMXK1-14004 ×Sukumar), P_1×P_3 (BMXK1-14004 × BINA Mung-8) displayed significant better parent heterosis and standard variety heterosis for seed yield per plant including its components.**

❑ **These crosses could be used in further breeding programs to select desirable segments by mating approach followed by selection in their segregating generations.**

References

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing sytems. *Aust. J. Biol. Sci.*, 9: 463-493.

Nath, A., S.R. Maloo, Srikanta Nath and G.S. Yadav. 2018. Combining ability analysis for seed protein and methionine content in green gram [*Vigna radiata* (L.) wilczek]. Indian J. Agric. Res., 52 (1): 34-39.

Viraj, R., M.S. Pithia, H.V. Solanki .2020. Combining ability analysis for yield and yield components in mungbean [*Vigna radiata* (L.) Wilczek]. Legume Research- An International Journal, 43 (1): 151-154.

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