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Studies on Heterosis and Inbreeding Depression for Yield and its Attributes in Mungbean [*Vigna radiata* (L.) Wilczek]

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ABSTRACT: Eight parents and their resulting 28 F_1's and 28 F_2's crosses were evaluated to study the extent of heterosis and inbreeding depression for yield and its attributing traits in mungbean. Significant positive heterosis was observed in eight crosses for seed yield per plant. This heterosis was observed in either mid-parent or both mid and better parent. Among these crosses, heterosis was coupled with low to high positive significant inbreeding depression in five crosses (HUM 1 × MH 421, HUM 1 × MH 2-15, MH 421 × LGG 460, PUSA 9531 × RMG 975 and LGG 460 × RMG 975). This suggested a considerable decrease in seed yield per plant due to the dissipation of dominance or dominance based interaction effects in the F_2 generations of these crosses. Heterosis coupled with inbreeding depression revealed the predominance of non-additive gene action for most of the characters studied. Hence, the cross combinations having desirable significant heterosis for a particular trait may be handled in advanced generations to get desirable combination for the improvement of mungbean crop.

Keywords: Mungbean, heterosis, heterobeltiosis, inbreeding depression.

INTRODUCTION

Mungbean is an economically important pulse crop ranking after chickpea and pigeon pea. It is an outstanding source of easily palatable, nutritive, high quality and easily digestible, non-flatulent proteins. The productivity of mungbean is low and is often related to its poor genetic makeup. Therefore, exploitation of heterosis breeding is gaining importance to get maximum yield. Heterosis is exploited in most of the field crops yet its usefulness remained unexplored in legumes mainly because most of these are highly self-pollinated and lack of male sterile lines. The exploitation of heterosis to raise productivity in grain legumes depends on the direction and magnitude of heterosis, feasibility of large scale production and involvement of type of gene action (Soehendi and Srinives 2005). In mungbean, the utility of heterosis *per se* may not be of much use but cross combinations can be used in developing high yielding pure line varieties (Singh, 1971). The exploitation of heterosis is a quick and convenient way of combining desirable genes present in different parents into a single genotype and has important implications for both in F_1 and for obtaining desirable transgressive segregants for many quantitative characters in advanced generations. Besides this, inbreeding depression indicates whether the vigor observed in segregating generations can be fixed in later generations by selfing (Joseph and Santoshkumar 2000). Information obtained from heterosis and inbreeding depression can be used to design appropriate breeding programs. Hence, with this background information, the present study was undertaken to know the information on mid parent and better parent heterosis and inbreeding depression for yield and its component traits in mungbean.

MATERIALS AND METHODS

Eight genetically diverse varieties of mungbean were crossed in half diallel fashion and their resulting F_1 and F_2 generations along with their parents were evaluated during *kharif* 2022 at Instructional Farm of S.K.N. College of Agriculture, Jobner. The experiment was laid out in randomized block design with three replications. Variable numbers of rows were used for different generations. Each plot of non-segregating generations (parents and F_1's) was sown in one row and F_2 generations in six rows. The row length of each plot was kept three meter long with inter and intra rows distance of 40 cm and 10 cm respectively. Ten plants in non-segregating generations (parents and F_1's) and 30 plants in F_2 generations from each plot in each replication were selected randomly. The observations on traits *viz.,* days to 90% pod maturity, plant height at 90% pod maturity, branches per plant, clusters per plant, pods per cluster, pods per plant, pod length (cm), seeds per pod, seed yield per plant (g), seed index (g) and seed protein content (%) were recorded on the tagged plants. The analysis of variance, heterosis and inbreeding depression were calculated as per Panse and

Sukhatme (1985); Fonseca and Patterson (1968); Allard (1960), respectively.

RESULTS AND DISCUSSION

The analysis of variance (Table 1) displayed that mean sum of squares due to genotypes and different components (parents, F_1's and F_2's) were significant for all the traits except for seeds per pod due to parents and F_2's. The presence of variation in parents has resulted into significant variations in hybrids as well. Further, the mean sum of squares due to P vs F_1 which gives an idea about the presence of overall heterosis was found to be significant for pod length. Likewise, the mean sum of squares due to F_1 vs F_2 which gives an idea about the presence of overall inbreeding depression was found to be significant for the traits *viz.,* days to 90% pod maturity, cluster per plant, pods per plant, pod length, seeds per pod, seed index and seed protein content.

Average heterosis, heterobeltiosis and inbreeding depression in 28 crosses of mungbean for different quantitative traits are presented in Table 2. The magnitude of average heterosis for seed yield per plant ranged from -33.09 (ML 818 × MH 2-15) to 35.43 per cent (LGG 460 × RMG 975), heterobeltiosis ranged from 2.79 (MH 421 × RMG 975) to 31.80 per cent (HUM 1 x RMG 975) and inbreeding depression ranged from -29.84(ML 818 × MH 2-15) to 23.31(HUM 1 × MH 2-15). The experimental results for heterosis revealed the significant positive average heterosis for seed yield per plant was manifested by eight crosses while six crosses exhibited significant positive heterobeltiosis for this trait. The significant negative inbreeding depression was noticed in three crosses (ML 818 × MH 2-15, IPM 205-7 × MH 421 and MH 421 × ML 818) only.

Among the component traits, the negative heterosis was considered to be desirable for days to 90% pod maturity and plant height at 90% pod maturity. In this respect, four crosses exhibited significant negative average heterosis for days to 90% pod maturity. The significant heterobeltiosis towards early days to 90% pod maturity was observed in two crosses (HUM 1 × RMG 975 and HUM 1 × LGG 460) and the significant positive inbreeding depression was shown by one cross (PUSA 9531 × ML 818) only. There was no significant manifestation of heterosis towards dwarfness at 90% pod maturity. However, a significant positive inbreeding depression was observed in three crosses.

The components such as branches per plant, clusters per plant, pods per cluster, pods per plant, pod length, seeds per pod and seed index directly contribute towards seed yield, therefore positive heterosis for these traits is desirable. Among the 28 crosses, significant positive average heterosis and heterobeltiosis for branches per plant were recorded in nine and six crosses, respectively and the significant negative inbreeding depression was manifested by five crosses. For clusters per plant, eleven and five crosses had significant positive average heterosis and heterobeltiosis, respectively and two crosses (ML 818 × MH 2-15 and PUSA 9531 × ML 818) exhibited significant negative inbreeding depression.

The data presented in Table 2 revealed the non-existent of significant heterosis and inbreeding depression in the desirable direction for pods per cluster. The significant positive average heterosis and heterobeltiosis for pods per plant were manifested by ten and four crosses, respectively. Two crosses (ML 818 × MH 2-15 and MH 421 × ML 818) exhibited significant negative inbreeding depression for pods per plant. The significant positive average heterosis for pod length was observed in eight crosses while two crosses (IPM 205-7 × PUSA 953 and LGG 460 × RMG 975) manifested significant positive heterobeltiosis. None of the crosses expressed significant negative inbreeding depression for pod length. For seeds per pod, the significant positive average heterosis was observed in three crosses while none of the crosses exhibited significant heterobeltiosis and inbreeding depression in the desirable direction. The significant positive average heterosis for seed index was manifested by five crosses and for this trait also, none of the crosses displayed significant desirable heterobeltiosis and inbreeding depression. For seed protein content, five crosses depicted significant positive average heterosis. The significant positive heterobeltiosis was observed in two crosses *viz.,* PUSA 9531 × RMG 975 and MH 2-15 × RMG 975. None of the crosses displayed significant negative inbreeding depression for this trait. The findings of current experiment regarding heterosis and inbreeding for different characters were analogous with the findings of Sawale *et al.* (2003); Dhurai *et al.* (2016); Narasimhulu *et al.* (2016); Purohit *et al.* (2017); Latha *et al.* (2019); Singh *et al.* (2021) in mungbean and Kant and Srivastava (2012); Shalini and Lal (2019) in urdbean.

CONCLUSIONS

Different hybrid combinations exhibited heterosis in both positive and negative directions, indicating the dominance of genes with either positive or negative effects. Additionally, there was significant variation in the degree of heterosis between different crosses, suggesting that the nature of gene action depended on the parents' genetic makeup. The close relationship between heterosis and inbreeding depression for most traits under different environmental conditions indicated the prevalence of non-additive genetic variance in the biological material being studied. Owing to its autogamous genetic architecture and biological constraints of the crop, the heterosis could be exploited only by isolating the desirable segregants for yield attributes by handling advanced generations.

Table 1: Analysis of variance for parents, F_1's and F_2's for different characters.

Characters	Source of variation							
	Rep.	Genotypes	Parents	F_1	F_2	P vs F_1	F_1 vs F_2	Error
	[2]	[63]	[7]	[27]	[27]	[1]	[1]	[126]
Days to 90% pod maturity	4.047	23.999**	39.119**	24.764**	17.171**	1.399	100.595**	2.534
Plant height at 90% pod maturity	53.974	116.783**	211.613**	107.714**	106.935**	69.858	34.381	18.752
Branches per plant	0.013	0.229**	0.174**	0.252**	0.237**	0.008	0.031	0.016
Clusters per plant	0.213	1.476**	0.953**	2.218**	0.945**	0.427	0.747*	0.139
Pods per cluster	0.041	0.301**	0.511**	0.354**	0.216*	0.004	0.002	0.122
Pods per plant	0.448	28.627**	28.945**	42.572**	16.173**	7.916	11.576*	2.657
Pod length (cm)	0.496	0.534**	0.688**	0.464**	0.443**	3.076**	2.701**	0.198
Seeds per pod	1.369	1.017**	0.824	1.246**	0.808	0.778	2.726*	0.525
Seed yield per plant (g)	0.048	1.594**	1.229**	2.612**	0.775**	0.224	0.298	0.236
Seed index (g)	0.079	0.292**	0.636**	0.337**	0.166**	0.118	0.352**	0.046
Seed protein content (%)	0.132	4.705**	3.894**	4.216**	5.426**	0.098	7.213**	0.339

[ ] Corresponding degree of freedom

*, ** Significant at 5% and 1% level of significance, respectively

Table 2: Extent of average heterosis (H), heterobeltiosis (HB) and inbreeding depression (ID) for different traits of mungbean crosses.

Crosses	Days to 90% pod maturity			Plant height at 90% pod maturity			Branches per plant			Clusters per plant		
	H	HB	ID	H	HB	ID	H	HB	ID	H	HB	ID
HUM 1 x IPM 205-7	3.80*	-	1.05	7.49	-	2.49	-5.56	-	11.76	1.05	-	6.22
HUM 1 x MH 421	0.26	-	0	1.68	-	0.47	-9.3	-	7.69	13.90**	11.52*	23.94**
HUM 1 x PUSA 9531	0.25	-	1.48	1.52	-	4.7	-29.79**	-	-6.06	4.2	1.64	10.22*
HUM 1 x LGG 460	-4.66**	-4.17*	-3.26	-1.59	-	5.09	-24.49**	-	8.11	10.20*	3.28	7.94
HUM 1 x ML 818	-2.11	0	-5.38*	9.63*	-	9.01	-8.7	-	4.76	-3.33	-	-1.15
HUM 1 x MH 2-15	-5.05**	-3.09	-3.19	8.83*	-	0.44	22.35**	13.04	17.31**	15.38**	6.56	8.72
HUM 1 x RMG 975	-5.18**	-4.69*	-2.73	2.82	-	5.94	36.96**	36.96**	4.76	9.38*	4.48	9.05*
IPM 205-7 x MH 421	-2.47	-	-3.93	3.47	-	11.34*	1.96	-	23.08**	-17.95**	-	-9.38
IPM 205-7 x PUSA 9531	-2.34	-	-1.06	-4.06	-	4.98	-16.36**	-	-21.74**	-4.02	-	2.23
IPM 205-7 x LGG 460	-2.73	-	-4.49*	-2.27	-	-5.15	-26.32**	-	14.29	-8.08	-	-3.64
IPM 205-7 x ML 818	3.89*	-	-2.14	3.03	-	-1.6	-9.26	-	14.29*	-4.26	-	1.11
IPM 205-7 x MH 2-15	1.06	-	-3.16	6.1	-	-7	-16.83**	-	7.14	-19.21**	-	-4.2
IPM 205-7 x RMG 975	2.73	-	-0.53	8.33	-	2.88	-31.48**	-	-21.62*	-1.5	-	-6.6
MH 421 x PUSA 9531	-1	-	-1.51	4.76	-	6.61	11.36	2.08	12.24	9.04*	4.19	5.03
MH 421 x LGG 460	-3.92*	-3.66	-7.61**	0	-	6.82	30.43**	15.38*	18.33**	11.11*	2.09	11.28*
MH 421 x ML 818	0.8	-	-5.79**	2.96	-	-3.35	11.63	4.35	-18.75**	-2.17	-	-3.89
MH 421 x MH 2-15	0.76	-	-3.54	12.38**	-	-8.05	6.33	5	-23.81**	1.16	-	0.57
MH 421 x RMG 975	-2.35	-2.09	-2.67	-4.45	-2.39	0.98	-2.33	-	-14.29	5.61	2.99	-1.93
PUSA 9531 x LGG 460	1.24	-	-0.98	7.44	-	11.92**	-26.00**	-	-5.41	-8.38	-	-2.61
PUSA 9531 x ML 818	6.30**	-	3.79*	11.11**	-	12.00**	-8.51	-	-13.95	-12.25**	-	-16.23**
PUSA 9531 x MH 2-15	3.15	-	-1.41	1.72	-	0	31.03**	18.75**	12.28*	17.33**	10.92*	9.84*
PUSA 9531 x RMG 975	-2.73	-	0.51	-3.18	-	-2.63	38.30**	35.42**	6.15	30.67**	21.89**	16.73**
LGG 460 x ML 818	-1.06	-	-5.35*	-6.54	-	-2.5	-4.08	-	-10.64	-9.2	-	-6.54
LGG 460 x MH 2-15	-2.03	-	-3.63	-0.9	-	-4.57	14.29*	0	-3.85	30.16**	28.12**	-4.88
LGG 460 x RMG 975	-0.52	-0.52	-2.09	-1.11	-	-7.21	34.69**	26.92**	10.61*	22.99**	10.45*	13.06**
ML 818 x MH 2-15	3.09	-	-3.5	5.88	-	-10.19*	12.94*	4.35	6.25	-23.49**	-	-26.77**
ML 818 x RMG 975	1.06	-	-3.66	-3.61	-	-9.5	6.52	6.52	0	-9.52*	-	-7.02
MH 2-15 x RMG 975	-2.03	-	-4.66*	7.23	-	5.65	27.06**	17.39*	-16.67**	14.61**	1.49	-0.49

Crosses	Pods per cluster			Pods per plant			Pod length (cm)			Seeds per pod		
	H	HB	ID	H	HB	ID	H	HB	ID	H	HB	ID
HUM 1 x IPM 205-7	1	0.17	10.42	1.92	-	15.84**	7.51	5.21	3.15	8.55	6.73	8.31
HUM 1 x MH 421	-1.17	-	5.23	13.02*	-	27.83**	5.45	-	7.76	11.32*	10.63	12.43*
HUM 1 x PUSA 9531	5.62	-	1.25	9.89	-	10.74	10.19*	3.48	3.78	-1.35	-	9.39
HUM 1 x LGG 460	1.96	-	-4.1	12.31*	2.41	4.3	8.07	6.76	5.43	6.93	4.2	5.76
HUM 1 x ML 818	-6.29	-	-4.55	-9.22	-	-5.53	3.48	-	3.59	9.47	7.91	5.57
HUM 1 x MH 2-15	6.99	-	9.8	20.60**	2.7	16.18**	6.54	0.88	5.7	4.06	-	-2.89
HUM 1 x RMG 975	8.47	-	6.33	19.72**	11.22	14.81**	7.2	6.93	8.8	7.74	5.45	5.17
IPM 205-7 x MH 421	-4.2	-	-0.32	-21.88**	-	-8.84	6.9	0.84	3.33	-2.63	-	-0.32
IPM 205-7 x PUSA 9531	4.67	-	0.64	-0.76	-	0.77	16.55**	11.74*	5.45	1.18	-	-2.33
IPM 205-7 x LGG 460	5.34	2.98	8.6	-3.74	-	5.59	4.31	3.32	-2.75	1.52	0.6	-4.78
IPM 205-7 x ML 818	-8.35	-	4.16	-12.71*	-	5.15	6.82	2.62	3.83	8.2	4.89	7.29
IPM 205-7 x MH 2-15	-1.95	-	-10.01	-22.11**	-	-15.16	-2.52	-	3.76	-11.54*	-	-0.67
IPM 205-7 x RMG 975	5.86	-	3.6	2.2	-	-4.02	5.34	2.84	0.92	0.76	0.3	0.91
MH 421 x PUSA 9531	1.13	-	2.12	11.15	7.82	6.91	8.12*	6.3	2.77	-5.79	-	-9.15
MH 421 x LGG 460	6.46	-	6.91	19.78**	13.28	17.20**	-0.22	-	1.35	-2.3	-	1.57
MH 421 x ML 818	-5.64	-	-13.3	-7.72	-	-17.36*	1.5	-	8.02	7.18	5	5.65
MH 421 x MH 2-15	-4.68	-	-12.66	-2.77	-	-11.79	4.74	2.1	1.23	-1.64	-	-4.56
MH 421 x RMG 975	5.34	-	-3.2	11.51	3.48	-5.28	11.16*	2.52	1.64	3.08	1.52	-1.79
PUSA 9531 x LGG 460	0.44	-	-0.87	-7.43	-	-4.02	2.97	-	0.89	-11.95**	-	-10.26
PUSA 9531 x ML 818	-5.95	-	-0.46	-17.01**	-	-16.93	-4.58	-	-1.83	-7.27	-	-4.9
PUSA 9531 x MH 2-15	2.45	2.4	3.87	20.77**	14.73*	13.31*	0.88	0	-2.61	-7.12	-	-3.68
PUSA 9531 x RMG 975	2.78	0	-3.65	35.88**	29.80**	13.90**	10.44*	3.48	2.94	5.42	1.98	1.67
LGG 460 x ML 818	-8.12	-	-2.94	-16.01*	-	-9.21	-2.29	-	-4.23	14.37**	9.91	12.84**
LGG 460 x MH 2-15	1.37	-	-1.93	32.09**	22.41**	-6.62	5.31	0.88	5.7	2.93	0.57	11.11*
LGG 460 x RMG 975	2.95	-	1.36	28.04**	25.50**	13.98**	12.75**	11.11*	5.65	9.80*	9.31	9.34
ML 818 x MH 2-15	-5.36	-	-3.62	-27.36**	-	-31.37**	-2.86	-	-1.81	-8.84	-	-11.37
ML 818 x RMG 975	-2.15	-	-4.39	-11.09	-	-11.88	11.16*	4.37	9.62*	8.32	4.55	4.06
MH 2-15 x RMG 975	0.48	-	-2.77	15.74*	5.3	-2.2	13.82**	7.52	8.64	5.15	2.29	11.20*

Crosses	Seed yield per plant (g)			Seed index (g)			Seed protein content (%)		
	H	HB	ID	H	HB	ID	H	HB	ID
HUM 1 x IPM 205-7	2.01	-	11.28	10.07*	-	-4.67	2.19	0.74	4.09*
HUM 1 x MH 421	14.90*	11.11	20.20**	5	-	0.3	4.18*	1.31	3.35
HUM 1 x PUSA 9531	13.10*	12.93	10.87	0.34	-	-6.8	3.23	0.75	-1.62
HUM 1 x LGG 460	7.23	6.82	1.33	-0.28	-	-10.54	1.67	1.01	6.31**

HUM 1 x ML 818	-8.34	-	-0.87	-7	-	6.49	-5.53**	-	-1.08
HUM 1 x MH 2-15	28.96**	28.16**	23.31**	-4.85	-	-2.78	-2.9	-	4.67*
HUM 1 x RMG 975	35.36**	31.80**	7.66	8.96	7.97	4.14	3.07	-	-1.05
IPM 205-7 x MH 421	-23.03**	-	-17.05*	1.48	-	3.38	2	0.59	-2.1
IPM 205-7 x PUSA 9531	2.91	-	8.11	12.45**	8.57	9.26	5.33**	1.38	0.99
IPM 205-7 x LGG 460	0.9	-	6.73	2.84	1.77	4.74	-0.49	-	2.26
IPM 205-7 x ML 818	-11.05*	-	7.89	2.48	-	6.4	-4.23*	-	4.49*
IPM 205-7 x MH 2-15	-23.94**	-	-10.86	-1.78	-	-4.94	0.52	-	2.94
IPM 205-7 x RMG 975	3.22	-	-5.73	6.57	-	10.79*	1.74	-	-1.47
MH 421 x PUSA 9531	9.71	6.25	3.47	2.9	-	1.53	-5.44**	-	3.43
MH 421 x LGG 460	19.76**	16.25*	15.85**	3.37	-	6.98	0.23	-	-2.79
MH 421 x ML 818	-13.52*	-	-16.87*	-0.82	-	8.83	-3.57*	-	5.36*
MH 421 x MH 2-15	-4.28	-	-7.97	10.67*	6.45	11.68*	-0.04	-	5.78**
MH 421 x RMG 975	9.06	2.79	-6.95	0.63	-	-2.18	6.98**	0.29	3.17
PUSA 9531 x LGG 460	-10.88	-	-12.21	-1.6	-	-5.14	-3.4	-	4.67*
PUSA 9531 x ML 818	-25.80**	-	-17.76	9.69*	-	14.42**	-2.78	-	2.05
PUSA 9531 x MH 2-15	9.91	9.39	5.13	6.26	3.19	1.35	-2.17	-	2.91
PUSA 9531 x RMG 975	33.56**	29.86**	16.15**	1.52	-	-7.78	7.08**	5.62*	1.28
LGG 460 x ML 818	-15.25*	-	-7.96	12.11**	0.88	6.38	-5.58**	-	4.60*
LGG 460 x MH 2-15	17.99**	17.71*	-4.96	-2.05	-	8.38	-2.52	-	3.82
LGG 460 x RMG 975	35.43**	31.38**	12.96*	5.16	-	6.58	-1.23	-	-3.65
ML 818 x MH 2-15	-33.09**	-	-29.84**	-10.15*	-	5.65	-6.82**	-	1
ML 818 x RMG 975	-14.79*	-	-14.59	-9.42*	-	-2.03	-5.92**	-	-4.51
MH 2-15 x RMG 975	11.13	7.56	-6.26	4.97	-	-6.56	5.16**	4.78*	2.94

*, ** Significant at 5% and 1% level of significance, respectively

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