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Combining ability analysis for yield, yield attributes and water use efficiency traits in mungbean

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Abstract

Twenty one F_1 crosses generated by crossing seven diverse mungbean genotypes *viz.*, ML-267, LGG-528, MGG-390, WGG-42, AKM-9904, LM-95 and EC-362096 in a 7 × 7 diallel fashion without reciprocals and their parents were evaluated for fourteen quantitative characters and three superior crosses *viz.*, ML-267 × LGG-528, MGG-390 × LM-95 and LM-95 × EC-362096 were identified on the basis of mean performance of yield and drought related traits**.** Hence, these crosses could be utilized in further breeding programmes to isolate desirable segregants by intermating approach followed by selection in their later segregating generations.

Keywords: mungbean, combining ability, water use efficiency

Introduction

Mungbean (*Vigna radiata* (L.) Wilczek) popularly known as green gram, is one of the important pulse crops of India. Among the wide array of pulses cultivated in India, mungbean ranks third in position after Bengal gram and redgram. It is an excellent source of high quality protein in the form of dry edible seeds and fresh sprouts. Being rich in quality proteins, minerals and vitamins, it is an inseparable ingredient in the diets of vast majority of population in the Indian subcontinent. Mungbean may also be sown as an intercrop or as a green manure or cover crop. Our nation’s production and productivity levels of mungbean are low and among several reasons for low productivity, various biotic and abiotic factors play major role. Among the abiotic stresses, drought is a wide spread problem that seriously influences the mungbean productivity. Realizing the significance of drought on yield components there is an immediate need to work in order to enhance the genetic potential of mungbean genotypes with high yield and drought and heat tolerance. In a crop improvement programme, much of the success rests upon isolation of valuable gene combination as determined in the form of lines with high combining ability. Combining ability determined through diallel analysis is useful to assess the nicking ability of the parents and at the same time, it elucidates the nature and magnitude of different types of gene actions involved. Combining ability is an estimation of the value of genotypes on the basis of their offspring performance in some definite mating design. Combining ability estimates can be used to evaluate inbred lines which is quite helpful in selecting the potential parents for hybridization. It is especially useful to study and compare the performances of lines in hybrid combination.

Materials and Methods

The present experiment was carried out at dry land farm of Sri Venkateswara Agricultural College, Tirupati, situated at an altitude of 182.9 m. above mean sea level, 32.27°N latitude and 79.36°E longitude, situated geographically in southern agro climatic zone of Andhra Pradesh, India. The soil is sandy loam with medium fertility. Seven parents *viz.*, ML-267, LGG-528, MGG-390, WGG-42, AKM-9904, LM-95 and EC-362096 were raised in paired row method for effecting crosses in a diallel fashion without reciprocals to generate seed of 21 F_1 crosses. The 21 F_1 crosses along with their seven parents constituted 28 treatments for this experiment. The seven parents and their 21 F_1 crosses were sown in randomized block design with two replications during the first fortnight of November, 2016 at dry land farm, S.V. Agricultural College, Tirupati. Each genotype was sown by dibbling the seeds in two rows of 3 m length, with a spacing of 30 cm between the rows and 10 cm between the plants.

All the 28 treatments were allotted at random to the experimental plots in each replication. The crop was fertilized at the rate of 20 kg N and 40 kg P_2O_5 in the form of urea and single super phosphate at the time of sowing. Thinning was done to leave single seedling per hill after 15 days of sowing. Irrigation, weeding and plant protection measures were taken up as and when needed during the crop growth period, as per the standard recommended package of practices to raise a good and healthy crop. Observations were recorded on five randomly chosen competitive plants from each genotype in each replication for the characters *viz*., plant height, number of branches per plant, number of clusters per plant, pods per cluster, pods per plant, seed yield per plant, 100-seed weight, harvest index, SLA, SCMR, SLW and relative injury. Days to 50% flowering and days to maturity were recorded on plot basis. The combining ability analysis was carried out according to Model I and Method II of Griffing (1956) [4]. The fixed effect model (Model I) was considered to be more appropriate in the present investigation, since the study was restricted to the parents and direct crosses only.

Results and Discussion

Analysis of variance for combining ability using diallel mating design for 14 characters and ratio of *gca* to *sca* variance for yield, yield attributes and drought related traits was presented in the Table 1. The mean squares due to *gca* were significant for all the characters except days to 50% flowering, number of pods per cluster, harvest index and SPAD chlorophyll meter reading. The mean squares due to sca were significant for all the characters. The magnitude of the mean squares due to *gca* was more than that of the *sca* for plant height, number of branches per plant, number of clusters per plant, number of pods per plant, 100 seed weight, specific leaf area and seed yield per plant. Days to 50% flowering, days to maturity, number of pods per cluster, harvest index, SPAD chlorophyll meter reading, and relative injury have shown high magnitude of mean squares due to *sca* than mean squares of *gca.* From this analysis, it was evident that both additive and non-additive gene action are important in the inheritance of these characters. The ratio of σ^2 *gca* to σ^2 *sca* was less than unity for all the characters except plant height indicating the preponderance of non-additive gene action in control of these traits.

The character wise estimation of general combining ability effects for each parent is presented in Table 2. The salient features of general combining effects of different characters are given below. The parents were classified as good and poor combiners based on estimates of general combining ability effects. The *gca* effects of the parents revealed that none of the parents was found to be good general combiner for all the characters. An overall examination of *gca* effects revealed that parent ML 267 was found to be good general combiner for eight characters *viz*. days to maturity, plant height, number of branches per plant, number of clusters per plant, number of pods per plant, specific leaf weight, relative injury and seed yield per plant. The second good general combiner is EC 362096 for five characters *viz*. plant height, hundred seed weight, specific leaf area, specific leaf weight and relative injury followed by MGG 390 for four characters *viz*. number of clusters per plant, number. of pods per plant, specific leaf area and seed yield per plant. In the present study, an overall appraisal of *gca* effects revealed that ML 267 and EC 362096 were good combiners for the majority of characters.

The estimates of *sca* effects of 21 crosses in F_1 generation for 14 quantitative characters were furnished in Table 3. The cross combination WGG 42 × LM 95 was the best for earliness with highly significant negative *sca* effects for days to 50% flowering and days to maturity indicating the role of non-additive gene action and is expected to produce desirable transgressive segregants in subsequent generations. Diallel mating or intermating in segregating populations followed by cyclic selection can be practiced for improving this trait in this cross. Similar findings were reported by Narasimhulu *et al.* (2015) [5] and Anamika *et al.* (2018) [1].

An examination of *sca* effects revealed that the crosses *viz.*, WGG 42 × AKM 9904 and ML 267 × LGG 528 were found to be best specific cross combinations for plant height as they displayed highly significant and positive *sca* effects.

The cross ML 267 × LGG 528 involving one good general combiner as a parent showed significant positive *sca* effect for number of branches per plant. Breeding method involving selection, intermating the selections and reselection may help to improve this trait in this cross. These results were in agreement with Yadav and Lavanya (2011) [10] and Govardhan *et al.* (2017) [3].

The cross ML 267 × LM 95 (good × good) displayed significant *sca* effects for number of clusters per plant, number of pods per cluster and number of pods per plant. This cross may be exploited through the simple pedigree method for improvement of these characters. These findings were in accordance with Sathya and Jayamani (2011) [7].

The crosses *viz*., ML 267 × MGG 390 (poor × poor), MGG 390 × LM 95 (poor × poor), WGG 42 × AKM 9904 (good × poor), WGG 42 × LM 95 (good × poor), LM 95 × EC 362096, (poor × good) were exhibited positive and significant *sca* effects for100-seed weight. These crosses could be handled by adopting cyclic selection of biparental mating programme for improving this trait. Similar kind of positive and significant *sca* effects were reported by Sathya and Jayamani (2011) [7], Patil *et al.* (2011) [6] and Govardhan *et al.* (2017) [3].

For harvest index, the cross LM 95 × EC 362096 (good × poor) has displayed highest significant *sca* effects followed by ML 267 × LGG 528 (good × poor) indicating the importance of non-additive gene action. These crosses can be exploited through biparental mating or intermating of selects followed by selection in later generations for isolation of breeding lines with high harvest index. This is in accordance with the findings of Sujatha and Kajjidoni (2013) [8] and Govardhan *et al.* (2017) [3] who reported positive *sca* effects.

Estimates of *sca* effects of crosses for seed yield per plant revealed that five crosses exhibited highly significant positive *sca* effects. The cross ML 267 × LGG 528, followed by LM 95 × EC 362096 and MGG 390 × LM 95 depicted maximum positive *sca* effects for seed yield per plant. Vaidya *et al.* (2016) and Eswaran and Anbanandan (2018) [2] also identified specific combiners for grain yield in their green gram material. The cross MGG 390 × LM 95 had displayed highly significant *sca* effects and the parents involved were good general combiners for this trait. Hence, there is a greater chance to get desirable transgressive segregants that can be handled through simple pedigree method in early generations.

MGG 390 and EC 362096 are the two good general combiners for specific leaf area as they displayed significant negative *gca* effects. It is interesting to note that the crosses *viz.*, MGG 390 × LM 95, MGG 390 × EC 362096, LM 95 × EC 362096 involving either MGG 390 or EC 362096 genotypes as one of the parents resulted significant and negative *sca* effects for this trait in desirable direction. Hence, inclusion of such parents in breeding program could provide an opportunity for expecting breeding lines with low specific leaf area in advanced segregating generations. These results were in congruent with the reports of Govardhan *et al.* (2017) [3].

The cross with good combining parents such as WGG 42 × EC 362096 showed positive *sca* effects for SCMR. This cross could be exploited through straight selection for improving the trait for respective conditions. The crosses *viz*., WGG 42 × EC 362096 (good × good), WGG 42 × AKM 9904 (good × poor), MGG 390 × LM 95 (poor × poor), ML 267 × LGG 528 (good × poor), ML 267 × MGG 390 (good × poor) displayed significant positive *sca* effects which had one parent with good or poor general combining ability. In these crosses, this trait can be exploited through biparental mating or intermating of selects followed by selection in later generations for isolation of breeding lines with high SCMR. Similar kind of positive effects was reported by Govardhan *et al.* (2015). Two crosses *viz*., LGG 528 × LM 95 and WGG 42 × EC 362096 exhibited significant *sca* effects in negative direction for specific leaf weight.

The crosses *viz*., ML 267 × LGG 528 (good × poor), ML 267 × AKM 9904 (good × poor), MGG 390 × WGG 42 (good × poor), LGG 528 × EC 362096 (poor × good), MGG 390 × LM 95 (good × poor), AKM 9904 × EC 362096 (poor × good) involving either one or both parents as good / poor general combiner displayed significant and negative *sca* effects for relative injury. Thus, these crosses can be handled through intermating the selections and reselection at later generations to produce desirable segregants with lower membrane leakage in mungbean. Similar findings were proclaimed by Govardhan *et al.* (2017) [3].

The results of specific combining ability effects of different crosses revealed that none of the crosses showed consistently significant and desirable specific combining ability effects for all the characters. However, three cross combinations *viz*., ML 267 × LGG 528, MGG 390 × LM 95, LM 95 × EC 362096 were adjudged as the best crosses for majority of the yield and water use efficiency related components.

The cross ML 267 × LGG 528 was found to be the best specific combiner as it showed highly significant *sca* effects in the desirable direction for twelve traits out of fourteen *viz.,* days to flowering, days to maturity, plant height, number of branches per plant, number of clusters per plant, number of pods per plant, harvest index, SCMR, SLA, specific leaf weight, relative injury and seed yield. The cross MGG 390 × LM 95 was another best cross which also registered highly significant desirable *sca* effects for twelve traits *viz*., days to flowering, days to maturity, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, 100 seed weight, harvest index, SCMR, SLA, relative injury and seed yield.

Further, the cross LM 95 × EC 362096 registered highly significant *sca* effects in desirable direction for ten traits *viz.* plant height, number of branches per plant, number of clusters per plant, number of pods per plant, 100 seed weight, harvest index, SLA, specific leaf weight, relative injury and seed yield. The cross combinations which expressed high *sca* effects for seed yield per plant, have invariable positive *sca* effects for one or more yield related traits.

Table 1: ANOVA for combining ability for fourteen traits in mungbean during *Rabi*, 2016

S. No.	Character	Mean Sum of Squares			σ^2 *gca*	σ^2 *sca*	σ^2 *gca* / σ^2 *sca*
		Gca (df = 6)	*Sca* (df = 21)	Error (df = 27)			
1	Days to 50% flowering	0.485	7.084**	0.620	-0.015	6.464	-0.002
2	Days to maturity	3.831**	3.965**	0.490	0.371	3.474	0.107
3	Plant height (cm)	23.911**	2.816**	0.892	2.558	1.925	1.329
4	No. of branches per plant	0.401**	0.172*	0.050	0.039	0.122	0.320
5	No. of clusters per plant	1.648**	1.639**	0.123	0.169	1.516	0.112
6	No. of pods per cluster	0.238	0.240*	0.098	0.016	0.142	0.110
7	No. of pods per plant	68.428**	47.283**	3.121	7.256	44.161	0.164
8	Hundred seed weight (g)	0.562**	0.379**	0.049	0.057	0.330	0.173
9	Harvest Index (%)	4.873	13.483**	4.383	0.054	9.100	0.006
10	Spad Chlorophyll Meter Reading	2.669	7.277**	1.777	0.099	5.499	0.018
11	Specific Leaf Area (cm2g-1)	616.256**	188.389**	12.633	67.069	175.756	0.382
12	Specific Leaf Weight (g cm-2)	0.000**	0.000**	0.000	0.000	0.000	0.365
13	Relative Injury (%)	39.384**	50.292**	1.416	4.219	48.876	0.086
14	Seed Yield per plant (g)	3.272**	3.064**	0.317	0.328	2.748	0.120

*: Significant at 5% level; **: Significant at 1% level

Table 2: Estimates of general combining ability (GCA) effects of seven parents for yield, yield attributes and water use efficiency traits in mungbean

S. No.	Parents	Days to 50% flowering	Days to maturity	Plant height	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of pods per plant
1	ML 267	0.05	-1.04**	1.14**	0.41**	0.41**	0.15	2.93**
2	LGG 528	0.05	0.24	-0.89**	-0.03	0.29*	0.04	1.07
3	MGG 390	0.05	-0.32	0.22	0.01	0.42**	0.16	2.62**
4	WGG 42	-0.40	-0.37	-3.13**	-0.16*	-0.64**	-0.32**	-4.56**
5	AKM 9904	0.38	0.79**	0.36	-0.24**	-0.39**	-0.09	-2.93**
6	LM 95	-0.12	0.74**	0.37	0.10	0.18	0.06	1.27*
7	EC 362096	-0.01	-0.04	1.94**	-0.09	-0.27*	0.01	-0.94
S.E. *gca* (i)		0.24	0.22	0.29	0.07	0.11	0.10	0.55

S. No.	Parents	Hundred seed weight (g)	Harvest index (%)	Spad chlorophyll meter reading	Specific leaf area (cm^2 g^{-1})	Specific leaf weight (gcm^{-2})	Relative injury (%)	Seed yield per plant (g)
1	ML 267	-0.12	0.70	0.25	6.00**	0.001**	-2.14**	0.41*
2	LGG 528	-0.23**	-0.12	-0.12	-3.42**	0.001**	0.20	-0.04

3	MGG 390	-0.18*	0.25	-0.93*	-2.64*	0.000	-0.62	0.53**
4	WGG 42	0.27**	-1.31	0.55	3.34**	0.001**	2.69**	-1.07**
5	AKM 9904	-0.01	0.31	-0.40	7.23**	0.001**	2.27**	-0.52**
6	LM 95	-0.16*	0.75	-0.03	5.64**	0.001**	0.54	0.55**
7	EC 362096	0.42**	-0.57	0.62	-16.15**	0.001**	-2.93**	0.13
S.E. *gca* (i)		0.07	0.65	0.41	1.10	0.00003	0.37	0.17

*: Significant at 5% level; **: Significant at 1% level

Table 3: Estimates of specific combining ability (sca) effects of 21 crosses for yield, yield attributes and water use efficiency traits in mungbean

S. No.	Crosses	Days to 50% flowering	Days to maturity	Plant height	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of pods per plant
1	ML 267 × LGG 528	-3.54**	-2.43**	2.94**	0.96**	1.29**	0.37	8.09**
2	ML 267 × MGG 390	3.96**	2.13**	1.13	-0.43*	-0.23	-0.04	-1.55
3	ML 267 × WGG 42	0.9	-1.32**	-2.21*	0.14	0.33	0.61*	4.23**
4	ML 267 × AKM 9904	0.13	0.01	-0.70	-0.58**	1.58**	0.16	6.86**
5	ML 267 × LM 95	0.13	1.57*	0.39	-0.32	0.91**	0.78*	9.90**
6	ML 267 × EC 362096	3.51**	0.35	0.22	-0.13	0.26	0.23	2.30
7	LGG 528 × MGG 390	1.46	1.85**	-0.65	-0.34	0.09	-0.18	-0.99
8	LGG 528 × WGG 42	0.9	3.90**	-0.49	-0.03	0.45	0.56	5.88**
9	LGG 528 × AKM 9904	3.13**	-0.76	0.72	0.05	0.89**	-0.74*	-2.79
10	LGG 528 × LM 95	0.63	-1.71**	-0.19	-0.24	0.68*	-0.04	1.85
11	LGG 528 × EC 362096	0.51	-0.43	0.74	0.01	1.37**	-0.15	3.46*
12	MGG 390 × WGG 42	0.4	-2.04**	1.50	0.59**	0.88*	-0.20	0.91
13	MGG 390 × AKM 9904	-0.88	-1.71*	-0.29	-0.18	0.37	-0.17	0.07
14	MGG 390 × LM 95	-2.88**	-2.65**	0.70	0.68**	1.11**	0.62*	9.61**
15	MGG 390 × EC 362096	-0.99	-0.38	0.33	-0.18	0.45	0.51	5.82**
16	WGG 42 × AKM 9904	-2.93**	-2.15**	3.76**	-0.06	-0.07	-0.26	-1.75
17	WGG 42 × LM 95	-3.93**	-3.10**	0.35	-0.04	-0.68*	-0.54	-6.22**
18	WGG 42 × EC 362096	-3.04**	-0.32	0.39	-0.06	-1.69**	-0.05	-5.60**
19	AKM 9904 × LM 95	-0.71	1.24	0.66	0.53*	-1.14**	-0.21	-5.59**
20	AKM 9904 × EC 362096	-2.32**	1.01	-1.90*	0.22	-0.09	0.45	2.63
21	LM 95 × EC 362096	-0.82	0.07	2.39*	0.48*	1.84**	-0.18	4.46*
S.E. *sca* (ii)		0.601	0.535	0.721	0.170	0.268	0.239	1.349
S.E. *sca* (ij)		0.707	0.629	0.848	0.200	0.315	0.281	1.586

*: Significant at 5% level; **: Significant at 1% level Cont…

S. No.	Crosses	Hundred seed weight (g)	Harvest index (%)	Spad chlorophyll meter reading	Specific leaf area (cm^{2}g^{-1})	Specific leaf weight (gcm^{-2})	Relative injury (%)	Seed yield per plant (g)
1	ML 267 × LGG 528	0.28	7.76**	2.95*	-27.28**	0.001**	-10.96**	3.27**
2	ML 267 × MGG 390	0.85**	-0.09	2.70*	4.95	0.0000	1.16	-1.19*
3	ML 267 × WGG 42	-0.67**	3.65	-2.53*	11.59**	0.001**	0.34	0.07
4	ML 267 × AKM 9904	-0.04	-1.92	-0.23	5.13	0.0000	-2.28*	1.84**
5	ML 267 × LM 95	0.13	-0.25	-1.86	8.96*	0.001**	8.46**	1.71**
6	ML 267 × EC 362096	-0.42*	-0.42	0.41	-2.03	0.0000	1.05	-0.42
7	LGG 528 × MGG 390	0.34	-1.92	-2.48	4.13	0.0000	5.75**	-0.76
8	LGG 528 × WGG 42	-0.52*	2.42	-1.76	0.80	0.0000	5.01**	0.96
9	LGG 528 × AKM 9904	0.18	-0.28	-2.56*	12.10**	0.001**	2.95*	-0.41
10	LGG 528 × LM 95	-0.48*	-0.51	2.21	21.74**	-0.001**	3.85**	-0.23
11	LGG 528 × EC 362096	0.11	-1.70	0.92	13.31**	0.001**	-5.84**	-0.35
12	MGG 390 × WGG 42	-0.36	-2.34	-1.25	-4.08	0.0000	-4.81**	-0.29
13	MGG 390 × AKM 9904	-0.22	-0.78	0.65	2.18	0.0000	-1.70	-0.47
14	MGG 390 × LM 95	0.45*	5.59**	3.66**	-7.67*	0.0000	-11.56**	2.93**
15	MGG 390 × EC 362096	-0.85**	0.53	-3.12*	-11.79**	0.001**	10.31**	0.75
16	WGG 42 × AKM 9904	1.09**	1.85	4.32**	-8.66*	0.0001*	1.88	0.58
17	WGG 42 × LM 95	0.84**	0.60	0.84	2.72	0.0000	3.65**	-0.60
18	WGG 42 × EC 362096	0.99**	-1.62	5.45***	19.99**	-0.001**	4.82**	-1.72**
19	AKM 9904 × LM 95	-0.39	-4.43*	-3.67**	-3.56	0.0000	6.07**	-2.23**
20	AKM 9904 × EC 362096	0.00	0.88	0.65	12.78**	0.001**	-11.73**	0.44
21	LM 95 × EC 362096	0.80**	7.91**	1.12	-28.66**	0.001**	-13.03**	3.18**
S.E. *sca* (ii)		0.169	1.599	1.018	2.714	0.00008	0.909	0.429
S.E. *sca* (ij)		0.199	1.879	1.197	3.190	0.00010	1.068	0.505

*: Significant at 5% level; **: Significant at 1% level

Conclusions

From the above discussion, it is concluded that the crosses *viz.*, ML 267 × LGG 528, MGG 390 × LM 95, LM 95 × EC 362096 were identified as best specific cross combinations for most of the yield attributes together with a few drought tolerant traits. Hence, these crosses could be utilized in further breeding programmes to isolate desirable segregants by intermating approach followed by selection in their later segregating generations.

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