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Identification of Best Parents based on *per se* Performance and *gca* Effects for Yield and Water use Efficiency Related Traits in Mungbean

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ABSTRACT

Background: Among the constraints for low yield of mungbean, drought stress and heat stress are prominent. Water deficits and high temperature occur together in many environments and both stresses can interact to reduce yields. Thus, combination of water use efficiency and high temperature tolerance traits are relevant rather than a single trait used as selection criteria for screening appropriate plant ideotype. The present study is contemplated to identify superior parents for yield, yield attributes, water use efficiency and thermo tolerance related traits through combining ability analysis.

Methods: Twenty one F_1 crosses were 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. Further, 21 F_1 crosses along with seven parents were evaluated to study the the mean performance of the seven parents and their 21 F_1 crosses and combining ability of the parents and crosses and gene action for yield, yield components and water use efficiency related traits.

Result: The present investigations confirmed that some of the parents with significant positive *gca* effects for seed yield per plant and showed significant positive *gca* effects for one or more yield, WUE and heat stress tolerance contributing traits. Combination of mean performance and *gca* effects would result in the selection of potential parents with good reservoir of superior genes. The parents which exhibited high *per se* performance also displayed good general combining ability effects. Hence, *per se* performance may be used effectively for the selection of parents. In the present study, MGG 390, ML 267 and EC 362096 were adjudged as the best parents based on both mean and *gca* effects.

Key words: Combining ability, Heat stress tolerance, Mungbean, Water use efficiency, Yield attributes.

INTRODUCTION

Mungbean popularly known as green gram [*Vigna radiata* (L.) Wilczek] occupies predominant position in the pulse basket in terms of dietary elements and agronomic aspects. Genetic enhancement for yield and quality seed would be a critical factor in productivity. Among the constraints for low yields of mungbean, drought stress and heat stress are prominent. Water deficits and high temperature occur together in many environments and both stresses can interact to reduce yields. Improving the tolerance of crops to drought requires a broader interdisciplinary approach for understanding factors determining yield and identification of reliable physiological traits. Plant scientists are making concerted efforts in identifying genotypes with high yield coupled with relatively better drought tolerance. Combination of different water use efficiency and high temperature tolerance traits are relevant, rather than a single trait used as selection criteria for screening appropriate plan.

More rapid progress may be achieved by a prior knowledge of the physiological basis of surrogate traits related to WUE, such as specific leaf area (SLA), soil and plant analytical development chlorophyll meter reading (SCMR) and specific leaf weight (SLW). SLA is negatively correlated with WUE whereas SCMR is positively associated with WUE. Hence, these traits could be used for selecting higher water use efficient green gram genotypes. Heat tolerance is determined by measuring relative injury percentage. Cell membrane integrity is tested by exposing leaves to high temperature and computing relative injury to the membranes in terms of electrolytes leakage. Lower leakage indicates lower the injury and higher the thermo tolerance. Genetic enhancement for drought and heat stress tolerance could be justifiable through clear understanding of the performance of diverse mungbean genotypes for yield,

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yield contributing, water use efficiency and heat stress tolerance related traits.

General combining ability (*gca*) is an effective tool used in selection of parents based on performance of their progenies. The general combining ability effects of parents for various traits were estimated and accordingly parents were classified as good (G) and poor (P) general combiners and are used in further hybridization and breeding programmes (Arunachalam and Bandyopadhyay, 1979). The parents with significant *gca* effects in desired direction (positive or negative) were considered as good (G) general combiners and rest of them were regarded as poor (P) general combiners.

The concept of combining ability analysis helps in selection of superior parents when considered along with the mean performances. It also reveals about the nature of gene action involved and thus helps in framing a suitable breeding scheme for the amelioration of the characters under consideration. The estimates of combining ability along with *per se* performance of genotypes in a crop improvement program have a direct bearing upon the choice of breeding methodology to be followed and to identify the parents and crosses (Khattak *et al.,* 2004) which could be exploited for future breeding programme.

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, apart from practicing 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). 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

The estimates of combining ability along with *per se* performance of genotypes in a crop improvement program have a direct bearing upon the choice of breeding methodology to be followed and to identify the parents and

Table 1: Best parents identified based on *per se* performance and *gca* effects for yield and water use efficiency traits in mungbean.

Characters	Best parents based on		
	per se performance	*gca* effects	*per se* performance and *gca* effects
Days to 50% flowering	ML 267, LGG 528	WGG 42, LM 95	-
Days to maturity	ML 267, LGG 528	ML 267, WGG 42	ML 267
Plant height (cm)	EC 362096, ML 267	EC 362096, ML 267	EC 362096, ML 267
Number of branches per plant	ML 267, MGG 390	ML 267	ML 267
Number of clusters per plant	MGG 390, WGG 42, LM 95	MGG 390, ML 267, LGG 528	MGG 390
Number of pods per cluster	AKM 9904, LGG 528, MGG 390	MGG 390	MGG 390
Number of pods per plant	MGG 390, LM 95, AKM 9904	ML 267, MGG 390, LM 95	MGG 390, LM 95
100-seed weight (g)	EC 362096, WGG 42	EC 362096, WGG 42	EC 362096, WGG 42
Harvest index (%)	AKM 9904, MGG 390	LM 95, ML 267	-
SPAD chlorophyll meter reading	MGG 390, EC 362096, AKM 9904	LM 95, MGG 390, ML 267	MGG 390
Specific leaf area (cm^2 g^{-1})	EC 362096, LGG 528	EC 362096, LGG 528	EC 362096, LGG 528
Specific leaf weight (g cm^{-2})	LGG 528, ML 267	EC 362096, WGG 42	-
Relative injury (%)	EC 362096, LGG 528	EC 362096, LGG 528	EC 362096, LGG 528
Seed yield per plant (g)	ML 267, MGG 390	EC 362096, ML 267	ML 267

Table 2: Mean performance of seven parents and 21 crosses for yield, yield attributes and water use efficiency related traits in mungbean.

Genotypes	DF	DM	PH (cm)	NBP	NCP	NPC	NPP	100-SW (g)	HI (%)	SCMR	SLA (cm^2 g^{-1})	SLW (g cm^{-2})	RI (%)	SYP (g)
ML 267	35.50	66.50	53.70	2.50	6.45	2.74	17.70	4.10	36.44	46.00	196.08	0.0051	40.59	7.52
LGG 528	36.50	69.00	49.00	1.25	5.90	3.65	21.50	3.98	36.29	46.35	165.50	0.0060	43.77	8.02
MGG 390	37.50	69.50	51.40	1.45	7.20	3.54	25.40	3.94	39.42	44.30	185.58	0.0054	42.94	9.91
WGG 42	41.00	70.50	44.40	1.10	6.80	2.79	18.90	4.25	34.52	44.80	180.22	0.0056	43.68	7.70
AKM 9904	40.50	71.50	51.90	1.05	6.15	3.70	22.60	4.06	42.37	45.85	189.20	0.0053	50.69	8.42
LM 95	41.50	72.50	50.90	1.35	6.70	3.38	22.65	3.42	36.46	45.15	199.24	0.0050	46.10	8.05
EC 362096	39.50	68.50	55.10	1.15	6.10	3.10	18.70	4.94	35.48	44.75	150.63	0.0066	45.09	8.65
Mean of parents	**38.86**	**69.71**	**50.91**	**1.41**	**6.47**	**3.27**	**21.06**	**4.10**	**37.28**	**45.31**	**180.92**	**0.0056**	**44.69**	**8.32**
Crosses														
ML 267 × LGG 528	33.00	65.50	55.50	2.35	9.70	4.04	39.20	4.33	47.75	49.30	160.00	0.0063	30.85	12.98
ML 267 × MGG 390	42.00	69.50	54.80	1.50	8.30	3.76	31.10	4.95	40.26	48.25	193.03	0.0052	42.15	9.09
ML 267 × WGG 42	38.50	66.00	48.10	1.90	7.80	3.93	30.40	3.88	42.45	44.50	205.65	0.0049	44.63	8.75
ML 267 × AKM 9904	38.50	68.50	53.10	1.10	9.30	3.71	34.50	4.23	38.49	45.85	203.10	0.0049	41.60	11.07
ML 267 × LM 95	38.00	70.00	54.20	1.70	9.20	4.48	41.20	4.25	40.61	44.65	205.33	0.0049	50.61	12.00
ML 267 × EC 362096	41.50	68.00	55.60	1.70	8.10	3.88	31.40	4.28	39.11	47.50	172.55	0.0058	39.72	9.45
LGG 528 × MGG 390	39.50	70.50	51.00	1.15	8.50	3.51	29.80	4.33	37.61	42.70	182.79	0.0055	49.07	9.07
LGG 528 × WGG 42	38.50	72.50	47.80	1.30	7.80	3.78	29.50	3.92	40.40	44.90	185.45	0.0054	51.64	9.18
LGG 528 × AKM 9904	41.50	69.00	52.50	1.30	8.50	2.70	23.00	4.34	39.31	43.15	200.65	0.0050	49.16	8.37
LGG 528 × LM 95	38.50	68.00	51.60	1.35	8.85	3.54	31.30	3.53	39.53	48.35	208.69	0.0048	48.33	9.61
LGG 528 × EC 362096	38.50	68.50	54.10	1.40	9.10	3.39	30.70	4.70	37.02	47.65	178.47	0.0056	35.17	9.07
MGG 390 × WGG 42	38.00	66.00	50.90	1.95	8.35	3.14	26.07	4.13	36.00	44.60	181.34	0.0055	41.00	8.50
MGG 390 × AKM 9904	37.50	67.50	52.60	1.10	8.10	3.39	27.40	4.00	39.18	45.55	191.49	0.0052	43.69	8.88
MGG 390 × LM 95	35.00	66.50	53.60	2.30	9.40	4.32	40.60	4.52	45.99	49.00	180.00	0.0056	32.10	13.34
MGG 390 × EC 362096	37.00	68.00	54.80	1.25	8.30	4.17	34.60	3.80	39.61	42.80	154.14	0.0065	50.50	10.74
WGG 42 × AKM 9904	35.00	67.00	53.30	1.05	6.60	2.82	18.40	5.75	40.25	50.70	186.64	0.0054	50.59	8.33
WGG 42 × LM 95	33.50	66.00	49.90	1.05	6.55	2.69	17.60	5.35	39.46	47.65	196.42	0.0051	50.63	8.21
WGG 42 × EC 362096	34.50	68.00	51.50	1.20	5.10	3.14	16.00	6.08	35.91	52.85	191.90	0.0052	48.32	6.67
AKM 9904 × LM 95	37.50	71.50	53.70	1.90	6.35	3.25	20.40	3.85	36.03	42.20	194.04	0.0052	52.62	7.14
AKM 9904 × EC 362096	36.00	70.50	52.70	1.40	6.95	3.86	26.40	4.81	40.02	47.10	188.58	0.0053	31.35	9.39
LM 95 × EC 362096	37.00	69.50	57.00	2.00	9.45	3.38	31.90	5.46	47.50	48.00	150.55	0.0066	28.32	13.18
Mean of crosses	**37.64**	**68.40**	**52.78**	**1.55**	**8.11**	**3.57**	**29.12**	**4.50**	**40.12**	**46.53**	**185.99**	**0.0054**	**43.43**	**9.67**
Grand mean	**37.83**	**68.73**	**52.31**	**1.49**	**7.70**	**3.49**	**27.10**	**4.40**	**39.41**	**46.23**	**184.90**	**0.0055**	**43.75**	**9.33**
S.E (m)	0.79	0.70	0.95	0.25	0.35	0.31	1.77	0.22	2.09	1.34	3.57	0.0001	1.19	0.56
CD (5%)	2.28	2.03	2.77	0.72	1.02	0.91	5.12	0.64	6.07	3.89	10.37	0.0003	3.45	1.63
CV (%)	2.91	1.44	2.58	23.58	6.4	12.67	9.21	7.13	7.51	4.12	2.69	2.7700	3.85	8.53

DF: Days to 50% flowering; DM: Days to maturity; PH: Plant height; NBP: Number of branches per plant; NCP: Number of clusters per plant; NPC: Number of pods per cluster; NPP: Number of pods per plant; 100-SW: 100-Seed weight; HI: Harvest index; SCMR: SPAD Chlorophyll meter reading; SLA: Specific leaf area; SLW: Specific leaf weight; RI: Relative injury; SYP: Seed yield per plant.

Table 3: Estimates of general combining ability (*gca*) effects of seven parents for yield, yield attributes and water use efficiency related traits in mungbean.

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of pods per plant
ML 267	0.05	-1.04**	1.14**	0.41**	0.41**	0.15	2.93**
LGG 528	0.05	0.24	-0.89**	-0.03	0.29*	0.04	1.07
MGG 390	0.05	-0.32	0.22	0.01	0.42**	0.16	2.62**
WGG 42	-0.40	-0.37	-3.13**	-0.16*	-0.64**	-0.32**	-4.56**
AKM 9904	0.38	0.79**	0.36	-0.24**	-0.39**	-0.09	-2.93**
LM 95	-0.12	0.74**	0.37	0.10	0.18	0.06	1.27*
EC 362096	-0.01	-0.04	1.94**	-0.09	-0.27*	0.01	-0.94
S.E (gi)	0.24	0.22	0.29	0.07	0.11	0.10	0.55
Parents	100-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)
ML 267	-0.12	0.70	0.25	6.00**	0.001**	-2.14**	0.41*
LGG 528	-0.23**	-0.12	-0.12	-3.42**	0.001**	0.20	-0.04
MGG 390	-0.18*	0.25	-0.93*	-2.64*	0.000	-0.62	0.53**
WGG 42	0.27**	-1.31	0.55	3.34**	0.001**	2.69**	-1.07**
AKM 9904	-0.01	0.31	-0.40	7.23**	0.001**	2.27**	-0.52**
LM 95	-0.16*	0.75	-0.03	5.64**	0.001**	0.54	0.55**
EC 362096	0.42**	-0.57	0.62	-16.15**	0.001**	-2.93**	0.13
S.E (gi)	0.07	0.65	0.41	1.10	0.00003	0.37	0.17

*Significant at 5% level, **Significant at 1% level.

crosses (Khattak *et al*., 2004) which could be exploited for future breeding programme. Evaluation of parents based on mean performance and *gca* effects separately might lead to contradiction in selection of promising parents since mean performance of parents was not always associated with high *gca* effects. Combination of mean performance and *gca* effects would result in the selection of potential parents with good reservoir of superior genes (Singh and Harisingh, 1985).

Best parents identified based on per se performance and *gca* effects for yield, yield components and water use efficiency related traits was presented in the Table 1. The mean performance and gca effects of all the genotypes for yield, yield attributes and water use efficiency related traits were presented in the Table 2 and 3. Among the parents MGG 390, ML 267, LGG 528 and EC 362096 were adjudged as the best parents based on high *per se* values for more number of traits. Based on *gca* effects ML 267, EC 362096 and MGG 390 were adjudged as the best parents for majority of the traits.

In the present study, MGG 390, ML 267 and EC 362096 were adjudged as the best parents based on both mean and *gca* effects. The parent MGG 390 was good for four traits *viz.,* number of clusters per plant, number of pods per cluster, number of pods per plant and seed yield per plant whereas ML 267 was good for four different traits *viz.,* days to maturity, plant height, number of branches per plant and relative injury. The next best parent was EC 362096 which exhibited good mean performance and *gca* effects for four traits *viz.,* plant height, number of branches per plant, specific leaf area and specific leaf weight (Table 1).

Singh and Harisingh (1985) and Tiwari *et al.* (1993) had also suggested that parents with high *gca* effects could produce transgressive segregants in F_2 or later generations. Thus it was evident that the inclusion of MGG 390, ML 267 and EC 362096 as parents in crossing programme would result in the desirable segregants for high yield coupled with drought and heat stress tolerance in advanced generations.

The present investigation also confirmed that some of the parents with significant positive *gca* effects for seed yield per plant also showed significant positive *gca* effects for one or more yield, WUE and heat stress tolerance contributing traits. The parents which exhibited high *per se* performance also displayed good general combining ability effects. Hence, *per se* performance may be used effectively for the selection of parents. Similar results of positive association of *per se* performance and general combining ability and its usefulness in selection of the parents was also reported by Vijaykumar *et al.* (2017).

CONCLUSION

From the above discussion, it is concluded that the parents MGG 390, ML 267 and EC 362096 were adjudged as the best parents based on both mean and *gca* effects. Crosses involving these parents may throw desirable segregants for both yield attributing and WUE and heat stress tolerance related characters. Selection from the segregating generations of the crosses involving the above parents would be effective for genetic enhancement of yield, water use efficiency and heat tolerance.

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