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Combining Ability Analysis for Yield and its Component Traits in Blackgram (*Vigna mungo* (L.) Hepper)

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ABSTRACT

The present investigation was carried out in blackgram involving seven lines and three testers to identify the best combining parents and nature of gene action in association with yield and its component traits in blackgram. The parents were mated in the L × T method. The resultant twenty-one hybrids were evaluated for ten characters. The analysis variance due to SCA was higher than the GCA variance for all the characters except plant height indicating the preponderance of non-additive gene action. Based on *per se* performance and *gca* effect, the lines MDU 1, VBN (Bg) 4 and the testers TU 94-2, VBN 6 were adjudged as the best combiners for most of the traits. Among the hybrids, MDU 1/TU 94-2 followed by VBN (Bg) 4/VBN 6 exhibited high *per se* and *sca* effect for most of the economic traits. The hybrid MDU 1/TU 94-2 was found to be the best and could be exploited for further crop improvement. This promising hybrid may be forwarded further through pedigree breeding and selection in early generation to obtain high yielding segregants.

***Key words*:** Combining ability, *gca, sca*, Gene action, Blackgram

Blackgram (*Vigna mungo* (L.) Hepper) 2n=22 popularly known as urdbean belongs to the family Fabaceae. Blackgram is one of the important multipurpose pulse crop grown in arid and semi-arid tropics. It is photo insensitive and can be grown throughout the year. The relative drought tolerance and short duration of this crop makes it fit into any cropping system [1]. Blackgram contains amino acids, vitamins, fat (1.5 per cent), carbohydrates (60 per cent) and protein (25-26 per cent). It is a rich source of Vitamin A, B, B_{3a} and it contains small amount of niacin, riboflavin, thiamine and Vitamin C. Dry seeds of blackgram are good source of phosphorus [2]. In India, blackgram is cultivated in an area of about 35.53 lakh hectares with a production of 19.64 lakh tonnes and productivity is 553 kg per hectares. It is grown mainly in rainy and/or summer seasons. In Tamil Nadu, blackgram is grown in 0.36 lakh hectares with a production of 0.33 lakh tonnes per hectare [3]. The under production of blackgram in the country posed the situation of importing blackgram from other countries like Sri Lanka, Malaysia and Thailand to fulfill the dietary requirement of our present population [4]. To fulfill the national demands, there is a need to adapt a comprehensive crop improvement programme to develop a variety, which is adapted to various agro climatic conditions [5]. The success of breeding programme largely depends on the efficiency of choosing appropriate parents with good genetic potential. The knowledge of combining ability helps in identifying the best parents and it provides clues to the usefulness of individuals to be employed as the parents in the hybridization programme as well as simultaneously to screen the hybrids. So, the present study was carried out to elucidate the *gca* of parents and *sca* of hybrids and the nature of gene action.

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MATERIALS AND METHODS

The present investigation was carried out at the Plant Breeding Farm, Faculty of Agriculture, Annamalai University, Annamalainagar during February 2020. The seven lines (CO 5, Vamban 1, TMV 1, MDU 1, APK 1, VBN (Bg) 4 and ADT 5) and three testers (VBN 6, LBG 787 and TU 94-2) were crossed in a line x tester mating fashion resulting in 21 hybrids. Ten parents and their twenty-one hybrids were grown in a randomized block design (RBD) with three replications. A row spacing 30 cm and plant-to-plant spacing 10 cm were maintained for each cross. All the recommended general package of cultural practices and plant protection measures were adopted. Observations were recorded on ten randomly selected plants in each replication for the following traits viz., days to 50 per cent flowering, plant height, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, pod length, hundred seed weight and seed yield per plant. The mean values were computed for each genotype over three replications for each cross. The variances and the corresponding standard error of the mean were computed from the deviations of the individual values [6]. The combining ability variance analysis was based on the method developed [7].

RESULTS AND DISCUSSION

The analysis of variance for combining ability for various traits are presented in (Table 1). The analysis of variance revealed that mean squares due to hybrids, lines and testers were highly significant for all the traits. In the present study, the ratio of GCA to SCA variance was less than unity for all the characters like days to 50 per cent flowering, number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of seeds per pod, pod length, hundred seed weight and seed yield per plant indicating the preponderance of non-additive gene action. This is in accordance with the results [8-10]. The ratio of GCA to SCA variance was higher than unity for plant height indicating the preponderance of additive gene action. This is in conformity with the results [11-12].

Table 1 Analysis of variance for combining ability analysis

Source	df	Days to 50 per cent flowering	Plant height	Number of branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Number of seeds per pod	Pod length	Hundred seed weight	Seed yield per plant
Replication	2	0.2054	3.1195	0.0117	0.0061	0.0677	5.9186	0.0102	0.0026	0.0910	0.0655
Hybrid	20	12.7113**	51.8072**	3.8259**	7.3511**	2.0937**	707.6830**	0.4810**	1.2797**	0.0771**	15.5481**
Lines	6	27.6935**	155.7642**	4.9766**	12.7917**	3.1328**	938.1516**	0.7474**	3.5614**	0.1262**	16.7136**
Testers	2	14.6929**	21.6039**	3.9957**	26.4375**	1.9603**	569.1382**	0.7773**	1.1954**	0.2109**	83.2013**
L × T	12	4.8900**	4.8626**	3.2223**	1.6164**	1.5963**	615.5395**	0.2984**	0.1529**	0.0302	3.6898**
Error	40	1.4167	1.6717	0.0601	0.0926	0.0342	2.5665	0.0726	0.0362	0.0203	0.0941
GCA		0.2037	1.2225	0.0157	0.1493	0.0130	2.3996	0.0048	0.0293	0.0012	0.3088
SCA		1.1578	1.0636	1.0541	0.5079	0.5207	204.3243	0.0753	0.0389	0.0033	1.1986
GCA/SCA		0.1759	1.1493	0.0148	0.2939	0.0249	0.0117	0.0637	0.7532	0.3636	0.2575

**Significant at 1 per cent level

Table 2 *Per se* performance of lines and testers for yield and its component characters in blackgram

Parents	Days to 50% flowering	Plant height (cm)	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of pods per plant	No. of seeds per pod	Pod length (cm)	Hundred seed weight (g)	Seed yield per plant (g)
					Lines					
CO 5	38.42	54.63	4.44**	8.61**	3.33	34.60**	5.57	4.49	4.52	9.52**
Vamban 1	35.51	35.71**	4.13**	7.13	3.44	17.57	5.24	3.62	4.18	8.42
TMV 1	34.28	39.95	3.32	6.53	2.80	11.55	5.02	4.22	4.27	4.60
MDU 1	31.89**	31.71**	3.95	10.46**	4.14**	24.13**	6.06**	5.35**	4.80**	10.87**
APK 1	36.46	40.76	2.64	8.48**	3.46	19.94	5.37	3.36	3.98	8.38
VBN (Bg) 4	32.66*	35.51**	4.57**	8.96**	3.59	22.66	5.50	4.68**	4.04	9.92**
ADT 5	33.56	35.27**	1.91	4.71	3.15	10.67	5.17	3.64	4.56*	4.53
					Testers					
VBN 6	34.61	33.54	4.34**	7.12	3.93**	27.04**	5.85	4.86	4.76	9.74**
LBG 787	35.84	35.15	1.69	5.15	2.59	8.49	4.59	4.17	4.56	3.64
TU 94-2	31.44*	31.64	3.30	9.29**	3.79*	20.10	6.12**	5.04*	4.86	11.32**

*Significant at 5 per cent level; **Significant at 1 per cent level

Table 3 *Per se* performance of twenty-one hybrids for yield and its component characters in blackgram

Crosses	Days to 50% flowering	Plant height (cm)	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of pods per plant	No. of seeds per pod	Pod length (cm)	Hundred seed weight (g)	Seed yield per plant (g)
CO5/VBN 6	36.73	44.72	4.48**	9.55	5.61*	44.23**	5.15	5.68	4.76	11.75**
CO 5/LBG 787	35.58	45.32	2.61	7.93	4.27	25.42	5.49	5	4.69	8.7
CO 5/TU 94-2	38.26	42.39	4.31*	8.67	5.05	35.99	5.46	5.42	4.79	12.43**
Vamban 1/VBN 6	34.53	33.44	4.23*	8.9	5.39	38.8	5.34	4.95	4.92	11.74**
Vamban 1/LBG 787	34.36	35.23	2.63	7.23	4.85	26.42	5.6	4.78	4.69	8.48
Vamban 1/TU 94-2	37.25	34.97	3.42	8.8	5.26	32.69	5.12	4.99	4.64	8.57
TMV1/VBN 6	35.31	36.39	4.26*	8.68	4.5	32.66	5.15	5.43	4.94	9.55
TMV 1/LBG 787	34.11	34.86	2.53	7.64	4.77	26.51	5.1	5.39	4.79	6.67
TMV 1/TU 94-2	37.23	34.16	3.18	9.73	4.54	27.48	5.19	5.31	4.77	10.29
MDU 1/VBN 6	31.52**	30.73**	5.88**	12.33**	6.86**	70.4**	6.04**	6.96**	5.21**	14.22**
MDU 1/LBG 787	33.77	33.72	2.58	9.79*	4.37	29.08	5.63	6.12*	4.88	9.61
MDU 1/TU 94-2	30.67**	29.49**	5.95**	12.91**	7.21**	81.01**	6.22**	7.04**	5.11**	15.24**
APK 1/VBN 6	36.21	36.96	3.32	9.84*	5.75**	46.52**	5.18	5.72	4.71	10.63
APK 1/LBG 787	34.48	35.67	2.91	8.5	4.89	32.4	4.49	5.41	4.63	8.55
APK 1/TU 94-2	37.43	33.55	4.35**	9.76*	5.28	40.41	5.55	5.89	4.8	11.44**
VBN (Bg) 4/VBN 6	32.18*	31.54**	5.22**	11.46**	6.57**	58.47**	5.85*	6.73**	5	13.25**
VBN (Bg) 4/LBG 787	34.2	34.73	2.53	8.44	4.55	33.62	4.87	5.94	4.76	8.67
VBN (Bg) 4/TU 94-2	33.66	32.34**	4.54**	9.51	5.48	42.28*	5.64	6.14*	4.58	12.52**
ADT 5/VBN 6	32.03**	32.2**	5.07**	10.37**	6.16**	52.44**	5.75	6.53**	4.96	12.94**
ADT 5/LBG 787	33.43	34.91	2.58	6.75	4.67	23.89	5.07	6.05	4.77	7.73

ADT 5/TU 94-2	34.77	33.43	3.13	7.9	4.66	25.11	5.52	6	4.71	10.16
General mean	34.65	35.27	3.80	9.27	5.27	39.33	5.40	5.78	4.81	10.62
SE	0.68	0.78	0.14	0.17	0.12	0.90	0.14	0.11	0.07	0.17
CD (P=0.05)	1.91	2.18	0.40	0.48	0.34	2.52	0.41	0.31	0.21	0.49
CD (P=0.01)	2.54	2.90	0.54	0.64	0.45	3.35	0.55	0.42	0.29	0.66

**Significant at 1 per cent level

The foremost step of any plant breeding programme should be the correct choice of good parents. Gilbert [13] suggested that the parents with high order of *per se* expression would be much useful in producing better genotypes. Mean performance of all the parents and their hybrids were presented in the (Table 2-3). In the present investigation, the lines MDU 1, VBN (Bg) 4 and CO 5 and the testers TU 94-2 and VBN 6 registered significant high mean values for seed yield per plant. The lines VBN (Bg) 4 and CO 5 showed high *per se* performance for number of branches per plant and number of pods per plant respectively. The cross combinations MDU 1/TU 94-2, MDU 1/VBN 6 and VBN (Bg) 4/VBN 6 exhibited superior performance for seed yield and the yield contributing characters.

Table 4 *gca* effects of lines and testers for yield and its component characters in blackgram

Parents	Days to 50% flowering	Plant height	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of pods per plant	No. of seeds per pod	Pod length	Hundred seed weight	Seed yield per plant
Lines										
CO 5	2.20**	8.87**	0.53**	-0.55**	-0.10	-0.76	-0.03	-0.42**	-0.07	0.33**
Vamban 1	0.73	-0.73	1.01**	-0.96**	1.12**	19.14**	-0.05	-0.88**	-0.07	-1.03**
TMV 1	0.90*	-0.14	-0.36**	-0.59**	-0.17**	-4.57**	-0.26**	-0.41**	0.02	-1.79**
MDU 1	-2.67**	-3.96**	-1.12**	2.41**	-0.59**	-9.99**	0.56**	0.92**	0.25**	2.40**
APK 1	1.39**	0.12	-0.66**	0.09	-0.52**	-8.16**	-0.33**	-0.11	-0.10*	-0.42**
VBN (Bg) 4	-1.31**	-2.41**	0.39**	0.53**	0.40**	7.73**	0.05	0.48**	-0.03	0.85**
ADT 5	-1.24**	-1.76**	0.21*	-0.93**	-0.13*	-3.39**	0.05	0.41**	0.00	-0.35**
SE (for lines)	0.39	0.43	0.08	0.10	0.06	0.53	0.08	0.06	0.04	0.10
Testers										
VBN 6	-0.58*	-0.13	0.24**	0.89**	0.23**	3.58**	0.10	0.22**	0.11**	1.39**
LBG 787	-0.38	1.07**	-0.50**	-1.23**	-0.35**	-5.97**	-0.22**	-0.26**	-0.07*	-2.28**
TU 94-2	0.96**	-0.94**	0.26**	0.34**	0.12**	2.40**	0.13*	0.04	-0.04	0.90**
SE (for testers)	0.25	0.28	0.05	0.06	0.04	0.34	0.05	0.04	0.03	0.06

*Significant at 5 per cent level; **Significant at 1 per cent level

Table 5 *sca* effects of hybrids for yield and its component characters in blackgram

Crosses	Days to 50% flowering	Plant height	No. of branches per plant	No. of clusters per plant	No. of pods per cluster	No. of pods per plant	No. of seeds per pod	Pod length	Hundred seed weight	Seed yield per plant
CO5/VBN 6	0.45	0.71	-0.08	-0.06	0.22*	2.09*	-0.31	0.1	-0.1	-0.59**
CO 5/LBG 787	-0.9	0.1	-0.32*	0.44**	-0.48**	-3.37**	0.34*	-0.11	0.01	0.02
CO 5/TU 94-2	0.45	-0.81	0.90**	-0.39*	0.17	2.42*	-0.03	0.01	0.08	0.58**
Vamban 1/VBN 6	-0.27	-0.97	0.41**	-0.3	0.57**	6.21**	-0.1	-0.17	0.06	0.76**
Vamban 1/LBG 787	-0.64	-0.39	-1.07**	0.15	-0.36**	-10.74**	0.47**	0.13	0.01	1.16**
Vamban 1/TU 94-2	0.91	1.37	-1.01**	0.15	-0.64**	-17.95**	-0.36*	0.04	-0.07	-1.92**
TMV1/VBN 6	0.34	1.39	-0.32*	-0.89**	-0.78**	-8.30**	-0.09	-0.16	-0.01	-0.67**
TMV 1/LBG 787	-1.06	-1.35	-0.38**	0.19	-0.13	-6.40**	0.18	0.27*	0.03	0.12
TMV 1/TU 94-2	0.72	-0.03	-0.50**	0.71**	-0.78**	-13.61**	-0.08	-0.11	-0.02	0.56**
MDU 1/VBN 6	0.11	-0.45	0.83**	-0.24	0.24*	8.36**	-0.02	0.04	0.03	-0.19
MDU 1/LBG 787	2.16**	1.33	0.41**	-0.66**	0.04	5.72**	-0.11	-0.33**	-0.12	-1.13**
MDU 1/TU 94-2	-2.28**	-0.88	1.50**	0.89**	1.42**	31.56**	0.13	0.29*	0.08	1.32**
APK 1/VBN 6	0.75	1.70*	-0.98**	-0.42*	-0.30**	-5.97**	0.01	-0.17	-0.12	-0.96**
APK 1/LBG 787	-1.19	-0.8	-0.03	0.36*	0.09	0.67	-0.36*	0	-0.01	0.63**
APK 1/TU 94-2	0.43	-0.9	0.1	0.05	-0.09	0.9	0.35*	0.17	0.13	0.34
VBN (Bg) 4/VBN 6	-0.59	-1.19	0.15	0.77**	0.06	-2.39*	0.3	0.25*	0.1	0.38*
VBN (Bg) 4/LBG 787	1.23	0.78	-0.85**	-0.13	-0.43**	-1.12	-0.36*	-0.08	0.05	-0.53**
VBN (Bg) 4/TU 94-2	-0.64	0.41	1.03**	-0.63**	0.69**	12.32**	0.06	-0.17	-0.15	0.14
ADT 5/VBN 6	-0.8	-1.18	1.39**	1.14**	0.84**	14.11**	0.21	0.12	0.03	1.28**
ADT 5/LBG 787	0.4	0.32	-0.05	-0.36*	0.26*	-1.31	-0.16	0.11	0.03	-0.26
ADT 5/TU 94-2	0.4	0.86	-1.14**	-0.78**	-0.60**	-13.22**	-0.06	-0.24*	-0.06	-1.01**
SE (*sca* effects)	0.68	0.74	0.14	0.17	0.10	0.92	0.15	0.10	0.08	0.17

*Significant at 5 per cent level; **Significant at 1 per cent level

Experimental results pertaining to *gca* effects of lines and testers were presented in (Table 4). Simmonds [14] quoted that the *gca* effect is considered as an intrinsic genetic value of the parent for a trait which is due to additive gene effect and it is fixable. Among the lines, MDU 1 recorded the maximum significant and positive *gca* for number of clusters per plant, number of seeds per pod, pod length, hundred seed weight and seed yield per plant. The lines MDU 1, VBN (Bg) 4 and the tester VBN 6 were found to be good general combiners for early flowering and pod length. The line MDU 1 and the tester TU 94-2 were identified as the best general combiners for short plant stature and number of seeds per pod. The lines Vamban 1, VBN (Bg) 4 and the testers TU 94-2, VBN 6 were found to be good general combiners for number of branches per plant, number of pods per cluster and number of pods per plant. The lines MDU 1 and VBN (Bg) 4 were good general combiners for number of clusters per plant. The line MDU 1 and the tester VBN 6 were found to be good general combiners for hundred seed weight. The lines MDU 1, VBN (Bg) 4, CO 5 and the testers TU 94-2, VBN 6 were the best general combiners for seed yield per plant. From the present study, the parents MDU 1, VBN (Bg) 4, TU 94-2 and VBN 6 were rated as the best since they possessed desirable *per se* and *gca* for most of the yield component characters. Hence, they can be further utilized for hybridization programme [15-16].

The specific combining ability is the deviation from the performance predicted on the basis of *gca* [17]. According to Sprague and Tatum [18], the specific combining ability is controlled by non-additive gene action. The *gca* effects is an important criterion for the evaluation of hybrids. The results of *sca* effects were depicted in (Table 5). From the study it was observed that the hybrid MDU 1/TU 94-2 showed significant and negative *sca* for days to 50 per cent flowering besides having significant and positive *sca* effect for number of branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, pod length and seed yield per plant. The hybrid Vamban 1/ LBG 787 was a good specific combiner for number of seeds per pod. The cross combinations MDU 1/ TU 94-2, VBN (Bg) 4/VBN 6 and ADT 5/ VBN 6 were found to be good specific combiners for seed yield and its component characters. The hybrid MDU 1/TU 94-2 was found to be the best and could be exploited for further crop improvement. This promising hybrid may be forwarded further through pedigree breeding and selection in early generation to obtain high yielding segregants.

CONCLUSION

The present study revealed that the line MDU 1 and the tester TU 94-2 were the best combiners and the hybrid MDU 1/ TU 94-2 was adjudged as the best since it possessed desirable per se and sca for most of the yield attributing characters. Hence this hybrid could be exploited for further crop improvement. The study also revealed the predominance of non-additive genetic control for all the economic traits except plant height.

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