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Combining Ability Analysis for Seed Yield and Component Traits over Season in Blackgram [*Vigna mungo* (L.) Hepper]

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ABSTRACT

Combining ability analysis over two seasons was carried out in blackgram involving four lines, five testers and 20 crosses. Variance due to environments was significant for all the characters. Variances due to genotypes and genotype x environment was significant for all characters, except for number of pods per cluster. It indicated that environment plays a major influence on the estimates of combining ability effects. The estimates of additive and dominance variances revealed preponderance additive gene action for all the characters, except number of pods per cluster. Parents *viz.*, MDU 1, Vamban 3, Mash 1008 and VBN 8 were good general combiners for seed yield per plant and yield component traits. Hybrids *viz.,* MDU 1 x Mash 1008 and MDU 1 x VBN 8 recorded high *per se* and non-significant *sca* effects for most of the characters including seed yield per plant indicating the role of additive gene action. Hence, these crosses could be used for further selection through pedigree breeding to obtain high yielding segregants.

Key words: Blackgram, Combining ability, Gene action, Seed yield.

INTRODUCTION

Blackgram [*Vigna mungo* (L.) Hepper] is an important food legume crop of Indian sub-continent. It is an important short duration crop and widely cultivated in India. It provides easily digestible good quality protein and has ability to improve the fertility of soil through symbiotic nitrogen fixation. The seeds are highly nutritious with protein (20-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. The biological value improves greatly, when wheat or rice is combined with blackgram because of the complementary relationship of the essential amino acids such as arginine, leucine, lysine, isoleucine, valine and phenylalanine, *etc*. (Mehra *et al.,* 2016). In India, the area under blackgram is about 4.50 million hectares with a production of 3.23 million tonnes (Annonymous, 2018). However, the productivity of blackgram is low which can be increased with the development and release of high yielding cultivars. Combining ability analysis is an important tool in assessing the usefulness of parents and understanding the magnitude of gene action involved in the inheritance of quantitative traits of economic importance. Assessment of combining ability in single season may not be precise as the environment may affect the estimates of combining ability. With this background the present investigation was attempted to estimate the general and specific combining ability of parents and hybrids, respectively for seed yield and its components in blackgram through line x tester mating analysis over two seasons.

MATERIALS AND METHODS

The experimental material consist of 20 F_1 hybrids developed by four lines (ADT 5, Vamban 3, CO 5 and MDU 1) and five testers (Mash 114, Mash 1008, VBN (Bg) 4, VBN 6 and VBN 8). All the lines, testers and cross combinations were grown in randomized block design with two replications at the National Pulses Research Center, Vamban during Summer 2018 and *Kharif* 2018. Each cross was raised in single row of 4 m length with 30x10 cm spacing. Recommended agronomic packages of practices for Tamil Nadu were followed to raise healthy crop. Nine quantitative characters were recorded *viz.,* plant height (cm), number of branches per plant, number of cluster per plant, number of pods per cluster, number of pods per plant, pod length (cm), number of seeds per pod, 100-seed weight (g) and seed yield per plant (g). Five randomly taken plants per entry were used for measuring traits. The data were subjected to statistical analysis. Pooled analysis for line x tester analysis was carried out using Windostat software (Indostat Private Limited Hyderabad) as per the procedure suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The pooled analysis of variance due to parents and hybrids for nine characters are presented in Table 1. It revealed

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that the variance due to environments was significant for all characters. Variances due to genotypes and genotype x environment was significant for all the characters, except number of pods per cluster. In case of analysis of variance for combining ability, variance due to environment was significant for all the traits, except for plant height and number of clusters per plant. Variances due to lines were significant for all the traits, except number of pods per cluster and number of pods per plant. These results indicated that lines had significant differences for *gca* effect for these traits. Variance due to tester was significant only for plant height. It indicated the presence of significant differences for *gca* effects of testers for this trait. Interaction effect of lines and testers was significant for number of clusters per plant, number of pods per plant, 100-seed weight and seed yield per plant. It indicates that *sca* effect of hybrids had significant differences for these traits. Environment x tester was significant for 100-seed weight while environment x line was not significant for any of the traits. It indicated that *gca* effects of testers for 100-seed weight alone had influence of environment. The *gca* effects of other traits of testers as well as of lines was not affected by the environment. The environment x line x testers variance was significant for all traits, except for plant height, pod length and 100-seed weight. It indicated that the *sca* effects of hybrids had significant influence of environment on all traits except plant height, pod length and 100-seed weight. The estimates of additive and dominance variances revealed the preponderance of additive gene action for all the characters, except number of pods per cluster (Table 2). Preponderance of additive variances in the expression of different characters in blackgram was also reported by Baradhan and Thangavel (2011), Cheralu *et al*. (1999), Dana and Das Gupta (2001), Govindaraj and Subramanian (2001), Singh Mohar (2008) and Thamodharan *et al.* (2015).

The success of any breeding programme largely depends on the choice of parents used in the hybridization. Gilbert (1958) suggested that the parents with good *per se* performance would result in better hybrids. Genotypes with high *per se* performance and high *gca* effects could be useful in evolving promising genotypes in the breeding programmes. The *gca* effect is due to additive gene action and fixable (Sprague and Tatum, 1942). Hence parents with desirable *per se* and gca effects need to be involved in breeding programmes.

Per se performance is an important and foremost criterion in the choice of parents in any plant breeding programmes.In the present study, lines *viz.,* MDU 1 and CO 5 were on par with the best check VBN 8 for seed yield per plant and other characters *viz.,* number of pods per cluster, number of pods per plant, pod length, number of seeds per pod and 100-seed weight (Table 3). Besides Vamban 3, CO 5 and MDU1 exhibited superior *per se* performance for number of clusters per plant. Among the testers Mash 1008

Table 1: Analysis of variance for parents and hybrids for yield and its component characters in blackgram.

Source of Variations	df	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield per plant (g)
Replicates	1	2.80	0.01	1.54	0.76	7.34	0.07	0.08	0.15	0.08
Environments	1	259.51**	4.68**	8.74*	9.06**	1846.97**	3.32**	36.56**	0.89**	228.73**
Genotypes	28	382.62**	0.94**	25.11**	0.40	194.82**	0.17**	0.43**	0.35**	7.10**
Environments *Genotype	28	37.13*	0.43**	9.39**	0.46	74.95**	0.14**	0.24**	0.10**	4.63**
Error	56	18.67	0.15	2.07	0.42	31.14	0.05	0.08	0.02	1.32

*, ** significant at 5 % and 1 % levels, respectively.

Table 2: Analysis of variance for combining ability analysis for yield and its component characters in blackgram.

Source of Variations	df	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield per plant (g)
Environments	1	26.85	3.74**	1.92	5.09**	1875.02**	3.81**	23.46**	1.61**	241.79**
Line effect	3	44.00**	1.46*	45.05*	0.14	361.71	0.28*	0.58*	1.46**	23.34**
Tester effect	4	1190.01**	0.34	18.85	0.10	213.17	0.07	0.05	0.22	3.55
Line*Tester effect	12	259.61	0.33	9.95**	0.12	107.70**	0.06	0.15	0.11**	3.32*
Env* Line effect	3	32.88	0.79	10.28	0.05	91.94	0.23	0.16	0.12	5.46
Env* Tester effect	4	12.03	0.40	10.07	0.14	57.94	0.12	0.14	0.18*	5.31
Env*L*T Effect	12	27.12	0.46*	8.73**	0.17*	79.18*	0.08	0.22*	0.04	4.01*
Error	38	24.28	0.18	1.52	0.09	38.98	0.05	0.10	0.03	1.51
A		78.46	0.08	3.32	-0.03	28.47	0.013	0.02	0.09	1.35
D		2.04	0.04	1.97	-0.07	19.14	0.001	0.01	0.02	0.49

*, ** significant at 5 % and 1 % levels, respectively.

recorded significantly high mean for number of clusters per plant and number of pods per plant. Parents *viz.,* ADT 5, Mash 114, Mash 1008, VBN 6 and VBN 8 had on par performance for plant height with VBN 8.The second criterion of selection of parents is the general combining ability effect of parents. Among lines MDU 1 recorded significantly positive for seed yield per plant and other characters *viz.,* number of clusters per plant and100-seed weight (Table 4). Vamban 3 had significantly positive *gca* for number of branches per plant, pod length, number of seeds per pod and 100-seed weight. ADT 5 and Mash 114 recorded significant negative *gca* effect of plant height. Among testers Mash 1008 was found to be a good general combiner for number of branches per plant, number of clusters per plant. VBN (Bg) 4 had good general combining ability for 100-seed weight. Griffing (1956) suggested that high *gca* effect is relative to additive type of gene action that represents the fixable genetic variation. Hence the genotypes with good combining ability effects for seed yield and component traits namely, MDU 1, Vamban 3, Mash 1008 and VBN (Bg) 4 may be considered as desirable for recombination breeding programme.

Among the hybrids MDU 1 x Mash 1008 and MDU 1 x VBN 8 recorded significantly superior seed yield per plant than best check VBN 8 (Table 5). These crosses also recorded superior mean for number of branches per plant, number of clusters per plant and number of pods per plant. In addition, the cross MDU 1 x VBN 8 also had superior mean for number of seeds per pod. Among these crosses, Vamban 3 x VBN (Bg) 4 showed superior mean performance for number of branches per plant, number of clusters per plant, number of pods per plant, number of seeds per pods and 100-seed weight. Hence the crosses *viz.,* MDU 1 x Mash 1008,MDU 1 x VBN 8, Vamban 3 x Mash 114 and Vamban 3

Table 3: Estimates of mean performance of parents for yield and its component characters in blackgram.

Source of Variations	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield per plant (g)
LINES									
ADT 5	25.29	1.45	7.65	2.22	18.45	5.19	5.62	3.78	3.04
Vamban 3	49.89	2.17	11.55*	2.28	25.34	5.45	5.70	3.76	4.19
CO 5	50.65	2.65*	10.55*	2.54	25.35	5.55	6.32	4.34	5.64
MDU 1	44.76	2.02	10.45*	2.65	26.72	5.36	6.57	4.52	6.80
TESTERS									
Mash 114	24.50	2.60*	7.35	2.28	17.70	5.29	6.22	4.23	3.02
Mash 1008	30.75	1.85	12.10*	2.65	31.20*	4.81	6.07	3.94	5.49
VBN (Bg)4	60.15	1.82	8.30	3.98*	25.05	5.28	5.97	4.30	4.32
VBN 6	29.85	1.67	8.16	2.73	23.80	4.93	6.27	4.47	4.60
VBN 8	27.68	1.88	6.75	2.45	19.82	5.24	6.12	4.32	5.02
SE	2.16	0.20	0.72	0.32	2.79	0.12	0.14	0.07	0.57
CD (0.05 %)	7.85	0.71	2.61	1.17	10.14	0.42	0.51	0.27	2.08

* Significantly superior than the check variety VBN 8.

Table 4: Estimates of general combining ability *gca* effects for yield and its component characters in blackgram.

Source of Variations	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield per plant (g)
LINES									
ADT 5	-10.64**	-0.39**	-1.98**	-0.06	-4.94 **	-0.13*	-0.16*	-0.37**	-1.07**
Vamban 3	3.69 **	0.21*	-0.05	-0.05	0.35	0.11*	0.17*	0.21**	-0.17
CO 5	7.18**	0.06	0.39	-0.02	-0.79	-0.07	-0.13	-0.02	-0.26
MDU 1	-0.24	0.12	1.64**	0.12	5.39**	0.09	0.12	0.18**	1.50**
TESTERS									
Mash 114	-5.99 **	-0.16	-1.83**	-0.08	-6.38 **	-0.01	0.06	-0.09*	-0.73*
Mash 1008	0.08	0.24*	0.97*	0.03	2.26	-0.10	-0.04	0.03	0.22
VBN (Bg) 4	5.37**	0.00	0.46	-0.07	2.38	0.01	-0.04	0.12*	0.47
VBN 6	0.20	-0.03	-0.01	0.11	0.48	0.03	0.06	-0.15**	-0.19
VBN 8	0.34	-0.04	0.41	0.01	1.27	0.07	-0.05	0.08	0.22
SE (gca lines)	1.10	0.09	0.28	0.07	1.40	0.05	0.07	0.04	0.28
SE (gca Tester)	1.23	0.10	0.31	0.07	1.56	0.06	0.08	0.04	0.31

*, Significant at 5 % level.

Table 5: Estimates of mean performance of hybrids for yield and its component characters in blackgram.

Crosses	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield per plant (g)
ADT5 x Mash 114	17.04*	2.07	7.60	2.38	15.85	5.37	6.52	3.74	3.05
ADT5 x Mash 1008	26.50	2.73*	12.55*	2.75	34.10*	5.12	6.33	4.11	5.12
ADT5 x VBN (Bg) 4	28.02	2.10	11.50*	2.64	31.60*	5.25	6.29	4.03	5.18
ADT5 x VBN 6	26.41	2.20	9.95*	2.73	26.50	5.50	6.63*	3.80	5.12
ADT5 x VBN 8	27.14	2.08	10.40*	2.64	26.20	5.37	6.27	4.27	4.80
Vamban 3 x Mash 114	37.32	2.80*	12.75*	2.67	32.00*	5.65	6.95*	4.65*	5.82
Vamban 3 x Mash 1008	40.60	2.68*	11.50*	2.55	28.15	5.55	6.90*	4.72*	5.31
Vamban 3 x VBN (Bg) 4	44.05	3.38*	13.65*	2.70	36.85*	5.60	6.70*	4.66*	6.77
Vamban 3 x VBN 6	39.25	2.85*	11.30*	2.70	30.45*	5.47	6.63*	4.50	5.40
Vamban 3 x VBN 8	35.55	2.50	12.40*	2.60	33.25*	5.57	6.52	4.35	4.47
CO 5 x Mash 114	35.90	2.62*	9.85*	2.49	22.25	5.14	6.13	4.16	4.95
CO 5 x Mash 1008	40.00	2.82*	12.30*	2.74	29.20	5.35	6.33	4.21	4.70
CO 5 x VBN (Bg)4	50.75	2.50	12.20*	2.30	28.30	5.53	6.60	4.54	5.89
CO 5 x VBN 6	44.40	2.77*	15.05*	3.03	39.40*	5.45	6.60	4.23	5.58
CO 5 x VBN 8	43.19	2.77*	14.40*	2.81	35.85*	5.45	6.52	4.59*	6.77
MDU 1 x Mash 114	28.43	2.38	11.95*	2.90	31.55*	5.61	6.92*	4.56	6.15
MDU 1 x Mash 1008	35.88	3.25*	17.05*	2.84	44.75*	5.40	6.58	4.55	8.66*
MDU 1 x VBN (Bg) 4	41.31	2.55	14.00*	2.84	39.93*	5.47	6.52	4.74*	6.95
MDU 1 x VBN 6	33.38	2.57	13.15*	2.74	32.75*	5.54	6.68*	4.31	6.05
MDU 1 x VBN 8	38.11	3.00*	13.95*	2.73	36.95*	5.71*	6.75*	4.58	8.32*
SE	2.16	0.20	0.72	0.32	2.79	0.12	0.14	0.07	0.57
CD (0.05 %)	7.85	0.71	2.61	1.17	10.14	0.42	0.51	0.27	2.08

* Significantly superior than the check variety VBN 8.

Table 6: Estimates of specific combining ability *sca* effects for yield and its component characters in blackgram.

Crosses	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of pods per cluster	Number of pods per plant	Pod length (cm)	Number of seeds per pod	100-seed weight (g)	Seed yield per plant (g)
ADT5 x Mash 114	-2.00	0.02	-0.96	-0.17	-4.62	0.06	0.05	-0.16	-0.87
ADT5 x Mash 1008	1.39	0.25	1.18	0.09	4.99	-0.10	-0.05	0.09	0.25
ADT5 x VBN (Bg) 4	-2.37	-0.14	0.64	0.08	2.38	-0.08	-0.08	-0.09	0.05
ADT5 x VBN 6	1.19	0.00	-0.44	-0.01	-0.83	0.14	0.15	-0.04	0.65
ADT5 x VBN 8	1.79	-0.12	-0.41	0.00	-1.92	-0.02	-0.08	0.19*	-0.07
Vamban 3 x Mash 114	3.96	0.12	2.27*	0.10	6.24	0.10	0.15	0.16	1.00
Vamban 3 x Mash 1008	1.16	-0.40	-1.80*	-0.13	-6.25	0.08	0.20	0.11	-0.47
Vamban 3 x VBN (Bg) 4	-0.68	0.54*	0.87	0.13	2.34	0.03	-0.01	-0.04	0.74
Vamban 3 x VBN 6	-0.30	0.04	-1.01	-0.05	-2.17	-0.13	-0.18	0.08	0.03
Vamban 3 x VBN 8	-4.14	-0.30	-0.33	-0.05	-0.16	-0.07	-0.17	-0.30**	-1.30*
CO 5 x Mash 114	-0.96	0.09	-1.07	-0.11	-2.37	-0.23*	-0.37*	-0.10	0.23
CO 5 x Mash 1008	-2.93	-0.11	-1.44*	0.04	-4.06	0.06	-0.07	-0.17*	-0.98
CO 5 x VBN (Bg)4	2.53	-0.20	-1.02	-0.30*	-5.08	0.14	0.20	0.07	-0.04
CO 5 x VBN 6	1.36	0.11	2.30*	0.25	7.91*	0.03	0.10	0.04	0.31
CO 5 x VBN 8	0.00	0.12	1.23	0.13	3.58	-0.01	0.14	0.16	0.49
MDU 1 x Mash 114	-1.00	-0.21	-0.23	0.17	0.75	0.08	0.17	0.10	-0.35
MDU 1 x Mash 1008	0.37	0.26	2.06*	0.01	5.31	-0.04	-0.08	-0.03	1.21
MDU 1 x VBN (Bg) 4	0.52	-0.20	-0.48	0.10	0.37	-0.09	-0.13	0.06	-0.75
MDU 1 x VBN 6	-2.24	-0.14	-0.86	-0.18	-4.92	-0.04	-0.08	-0.08	-0.99
MDU 1 x VBN 8	2.35	0.29	-0.48	-0.09	-1.50	0.09	0.11	-0.05	0.88
SE (sca)	2.46	0.21	0.62	0.15	3.12	0.12	0.15	0.09	0.62

*Significant at 5 % level.

x VBN (Bg) 4 were considered as desirable based on mean performance for seed yield and component traits. The specific combining ability is the deviation from the predicted performance on the basis of general combining ability (Allard, 1956).In contrast to *gca* effects, the *sca* effects represent dominance and epistatic variation that are not fixable. Among the crosses based on *per se* performance, the hybrids Vamban 3 x Mash 114 and Vamban 3 x VBN (Bg) 4 showed significant positive *sca* effect for number of clusters per plant and number of branches per plant, respectively. All other traits had non-significant *sca* effects in these two crosses. MDU 1 x Mash 1008 and MDU 1 x VBN 8 showed non-significant *sca*for all the traits, except for number of clusters per plant (Table 6). The present findings were also supported by the findings of Anbu Selvam and Elangaimannan (2010), Isha Parveen *et al.* (2012), Gill *et al.* (2014), Vijay Kumar *et al.*(2014) and Panigrahi *et al.* (2015). One of the parents involved in these crosses, MDU 1, was found to be a good general combiner for seed yield per plant, number of clusters per plant and number of pods per plant. The gene action involved in these crosses may be of additive type. Hence, MDU 1 x Mash 1008 and MDU 1 x VBN 8 may be used for further selection through pedigree breeding to obtain high yielding segregants.

In the present study, out of nine parents, MDU 1 recorded high *per se* performance and good general combining ability for seed yield per plant and other yield component traits. The hybrids *viz*., MDU 1 x Mash 1008 and MDU 1 x VBN 8, recorded high *per se* and additive type of gene action for seed yield and component traits. Hence, these crosses could be used for further selection through pedigree breeding to obtain high yielding segregants.

Contribution of author

Conceptualization of research (NM); Designing of the experiments (NM, AM, VKS and CV); Contribution of experimental materials (NM); Execution of field/lab experiments and data collection (KV); Analysis of data and interpretation (KV and NM); Preparation of the manuscript (KV, NM and AM).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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