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Combining Ability Studies Through Line × Tester Analysis in Black Gram (*Vigna mungo* (L.) Hepper)

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ABSTRACT

An investigation was carried out to study the general and specific combining ability in Black Gram (*Vigna mungo* (L.) Hepper) through Line × Tester analysis with seven lines and three testers. Six quantitative characters viz., plant height, number of branches per plant, number of clusters per plant, number of pods per plant, hundred seed weight and seed yield per plant in twenty-one hybrids and their parents are taken for the study. The analysis of variance showed significant differences among the genotypes for all the six characters studied. Based on high mean and general combining ability, the parents viz., H70-3, N 30-26 and VBN 2 were identified as potential parents. The F1 hybrids of the cross combinations viz., N 30-26 x VBN 2 and H 70-3 x VBN 1 was adjudged as superior. The above identified parents and cross combinations could be utilized in the future breeding programme for development of improved varieties.

***Key words*:** Black gram, Line x Tester, Per se performance, GCA, SCA, Non-additive action

Grain legumes occupy unique position in Indian agriculture. Besides forming a sustainable component of Indian agriculture, they are the major source of vegetable protein to the larger mass of the population as a basic vegetarian food. Pulses are important food crops as they have higher protein content (20-36 percent) compared with major cereals [1] specially to fulfil human nutritional requirement. The world population is projected to grow from the current 7.3 billion to 8.9 billion by 2050. Therefore, increasing food production and attaining nutritional security is a challenge. The 68th UN General Assembly declared year 2016 as the International Year of Pulses (IYP) to create public awareness of the nutritional benefits of pulse as part of sustainable food production. Among the pulses, Black gram (*Vigna mungo* (L.) Hepper) is one of the important grain legumes of the tropics and semi-arid tropics (SAT) and has been identified as a potential crop in many countries [2] including Bangladesh, Pakistan, Myanmar and Thailand. Locally it is called as kaali dal, urd bean, minapapappu, mungo bean or black matpe bean. This crop is utilized in several ways, as source of protein, as fodder and green manure and adapts well to various cropping systems owing to its ability to fix atmospheric nitrogen (N_2) in symbiosis with soil bacteria, rapid growth, and early maturity [3].

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Black gram belongs to the family Leguminoceae and sub family Papilionaceae. It is an important pulse crop of India and is mainly cultivated as a source of dietary protein because of the high protein content which is of about 25percent in dry seeds, 56 percent carbohydrate, 2 percent fat, 4 percent minerals [4]. They are rich in lysine, an essential amino acid which is found only at low levels in cereal protein [5]. It ranked fourth in pulses production next to chickpea, pigeon pea and mungbean. It is well known that 50g pulses/person/day should be consumed in addition to other sources of protein such as cereals, milk, meat and egg (WHO). It is a very difficult task to achieve this as the production and productivity of pulse crop including black gram is very low. Besides this, it contains macro and micronutrients (Ca, P, K, Fe, and Zn), vitamins (niacin, vitamin A, ascorbic acid, inositol), fiber and carbohydrate for balance nutrition.

The cultivation of legumes is beneficial to the succeeding cereal crop [6]. Black gram is more tolerant to water logging than mung bean. Total Black gram production in the world is about 2 million tonnes. India is the world's largest producer and consumer of black gram. It produces about 1.5 million tonnes of urad annually from 3.5 million hectares of area with average productivity of 500kg per hectare (DES Statistics, GOI, 2016 - 17). It is mostly grown in Madhya Pradesh, Maharashtra, Tamil Nadu, Uttar Pradesh, Rajasthan and Gujarat during kharif and Andhra Pradesh and West Bengal in rabi. Tamil Nadu produces about 1.21 lakh tonnes of urad annually from 3.41 hectares of area with average productivity of 354.84kg per hectare. However, the yield of this crop is very low because of the non- availability of high yielding cultivars and the lack of stability in performance of released cultivars across years. As a consequence, it is essential to develop varieties with high and stable yield to meet the growing demand

and to expand the area under its cultivation. Of the several methods, Line × Tester analysis [7] has been found to be the simplest but efficient biometric tool, provided the character is under the control of additive-dominance system without non-allelic interaction. The combing ability is an important tool for the selection of parents regarding nature and magnitude of gene effects controlling quantitative traits [8].

Significant gca and sca effects provide information to determine the efficacy of breeding for improvements in given traits and they can be used to identify the lines to be served as a parent in breeding programme for further improvement [9]. In addition, this technique enables the breeder to combine desirable genes that are found in two or more genotypes [10]. The present study is undertaken to study the combining ability, nature of gene action for six quantitative characters to study the gca and sca effects and variances of the parents and effected crosses.

MATERIALS AND METHODS

Ten Genotypes of Black gram collected from National Pulse Research Centre, Vamban were utilized for the present study. The experimentation was carried out at the Plant Breeding Farm, Faculty of Agriculture, Annamalai University, Annamalainagar, Tamil Nadu. These genotypes were mated in Line x Tester analysis, with RTU-14, AC 206, AKU-98-01, H70-3, AC-249, KMB-1, NO 30-26 as lines and VBN-1, VBN-2, VBN-5 as testers. Emasculation was carried out in yellowish green flower as described by Singh and Malhotra [11]. Crossing method in blackgram was done following the method adopted by Boiling *et al.* [12]. The resulting 21 hybrids along with their parents were evaluated in a randomized block design with three replications in a row of 4m length and adopting a spacing of 30 × 10cm. Recommended agronomic practices and need based plant protection measures were taken out for the better establishment of the crop. Observations were recorded for 10 randomly selected plants in each cross and parents per replication, with the following quantitative characters viz., plant height, number of branches per plant, number of clusters per plant, number of pods per plant, 100 seed weight and seed yield per plant. The data obtained from each character were analyzed by following the usual standard statistical procedure given by Panse and Sukhatme [13]. The variation among the hybrids were partitioned further into sources attributed to general and specific combining ability components as suggested by Kempthrone [7].

RESULTS AND DISCUSSION

The analysis of variance showed significant differences among the genotypes for all the six characters viz., plant height, number of branches per plant, number of clusters per plant, number of pods per plant, hundred seed weight and seed yield per plant. The success of any plant breeding programme depended to a greater extent on the knowledge of the genetic architecture of the population handled by the breeder [14]. It will be very advantageous if the parents themselves possess the desirable characters at a high level of expression [15]. In case of continuously varying traits like yield and its components which are under the control of large number of genes, the breeder needs special technique for the selection of efficient parents.

Line × Tester analysis which is one of the precise numerical tools for estimating combining ability which have important implication in production and selection of superior parents and potential hybrids for breeding programme [16] was employed for this present study. The analysis of variance indicated that parents and hybrids differed among themselves for most of the characters. This paved way for further analysis and interpretation so as to have meaningful conclusions. Such significant differences were already observed by few workers in blackgram [17-19]. In the present study, the parents and hybrids varied significantly for most of the characters studied. The combining ability of parents give useful information on the choice of parents in terms of expected performance of their hybrids and their progenies [20].

Table 1 Analysis of variance for line × tester in blackgram for six quantitative characters

Source of variation	Df	Mean squares					
		Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of pods per plant	100 seed weight (g)	Seed yield per plant (g)
Replication	2	1.81	3.23	0.27	4.17	0.01	1.56
Genotype	30	7.71**	4.72**	3.58**	36.33**	0.37**	7.48**
Cross	20	8.92**	3.92**	1.80*	8.79**	0.22**	8.98**
Line (L)	6	8.46	4.77	0.88	13.88	0.15**	4.94**
Tester (T)	2	2.87	1.20	2.02	3.87	0.45**	19.24**
Line × tester	12	10.16	3.94**	2.23**	7.06**	0.22**	9.29**
Error	60	2.54	1.38	0.87	3.06	0.01	0.62

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

Choice of parents

The success of any plant breeding programme largely depends upon the correct choice of good parents. High mean value was criteria for selection of superior parents. Gilbert [15] suggested that the parents with good *per se* performance would result in better genotypes. Further, the parents having high gca effects could be useful since, the gca effect is due to additive gene action and it is fixable [21], Sprague and Federer [22] and Rojas and Sprague [23] reported that gca involved both additive effects as well as additive x additive interactions. Kempthrone [7] defined precisely gca in terms of covariance of half sibs and full sibs in random population. Many workers had advocated gca effects to critically analyse the parents for their ability to transmit superior performance to their progenies. Kadambavanasundaram [24] suggested the importance of high and significant positive gca effects for yield and its component characters for better selection. It is better to choose parents possessing significant gca effects for hybridization rather than parents with low gca effects mainly based on the mean performance. This assumption is based on the principle that gca effect reflects additive gene action [25-26].

The parents which possess favourable gca effects of different characters should be used in crossing programme, so that, segregants could be obtained with superior performance for all the traits through recombination [27]. In the present study, the parents were evaluated based on *per se* performance and gca effects. The tester VBN-2 and the line AKU 98-01 recorded the high mean value for plant height. Similarly, the parent VBN-2 and H70-3 has high mean value for number of branches per plant, the tester VBN-2, VBN-5 has the high mean value for number of clusters per plant, the line no 30-26 and the tester VBN-2 recorded high mean for number of pods per plant. The parent VBN-1 and AC-249 has high mean for 100 seed weight and the line NO 30-26 and the tester VBN-2 recorded high mean for the seed yield.

Similarly, the parents RTU-14 and AC 206 has the positive gca effects for the plant height, the line AKU-98-01 and H70-3 has the high gca effects for number of branches per plant, the line AKU-98-01 and the tester VBN-5 has the high gca effect for number of clusters per plant. The parents H70-3 and AC-249 has the high gca effects for number of pods per plant. For 100 seed weight, the parents AKU-98-01 and VBN-5 recorded the high positive gca effects. The line NO 30-26 and the tester VBN-2 has the high gca effects for seed yield. The line NO 30-26 and the tester VBN-2 were adjudged as better parent, since it had high mean and significantly gca effects of, number of branches the traits viz., seed yield, plant height and yield contributing traits.

Choice of hybrids

Specific combining ability is the deviation from the performance predicted on the basis of general combining ability [28]. According to Sprague and Tatum [29] the specific combining ability is controlled by non-additive gene action and it is non-fixable. The sca values of any cross is helpful in predicting the performance of a particular hybrid in relation to the gca of its parents. The data on estimates of combining ability variances showed larger values of sca than gca for all the six characters indicating that non-additive or dominance gene action was predominant for the expression of these characters [30-35].

Table 2 General combining ability of parents

Parents	Plant height		Number of branches per plant		Number of clusters per plant		Number of pods per plant		100 seed weight (g)		Seed yield per plants (g)	
	Mean	gca	Mean	gca	Mean	gca	Mean	gca	Mean	gca	Mean	gca
Lines												
RTU-14	20.00	1.50**	6.00	0,17	4.00	-0,14	10.67	-1.49*	5.10	-0.05	6.09	-0.32
AC 206	19.00	1.61**	4.00	-0.83*	3.00	-0.14	5.33	-1.60**	4.53	-0.01	5.16	-0.84**
AKU-98-01	21.00	-0.17	5.67	-0.94*	4.00	0.41	12.67**	0.40	4.88	0.10**	7.86	0.37
H70-3	19.00	-0.28	6.00	0.95*	4.67	-0.14	10.33	1-95**	4.55	0.07*	7.68	0.65*
AC-249	18.00	-0-67	5.00	0.62	4.00	0.30	7.33	0.62	5.55**	-0.26**	6.32	-0.40
KMB-1	20.00	0.44	6.00	-0.38	5.00	0.19	6.33	0.29	4.28	0.08*	6.15	-0.63*
NO 30-26	17.50	0.22	3.33	0.40	6.00*	-0.48	14.67**	-0.16	5.15	0.07*	7.53	1.17**
Testers												
VBN-1	19.67	0.38	5,00	-0.25*	4.00	-0.32	7.00	-0.03	5.81**	-0.17	6.23	-0.19
VBN-2	22.17*	0.36	7.00	0.22	7.00**	-0.02	23.67**	0.44	4.63	0-10	6.73	1.04**
VBN-5	20.33	0.02	6.00	0.03	6.67**	0.32	8.00	-0.41	5.17	0.17	9.70**	-0.85**

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

Table 3 Specific combining ability of hybrids for different traits in black gram

Cross	Plant height		No. of branches per plant		No. of clusters per plant		No. of pods per plant		100 seed weight		Seed yield per plant	
	Mean	sca	Mean	sca	Mean	sca	Mean	sca	Mean	sca	Mean	sca
$L_1 \times T_1$	24.00**	2.62**	5.00	0.92	4.00	1.19*	6.33	-0.41	4.70	-0.19**	5.97	-0.-0.34
$L_1 \times T_2$	18.67	-1.98*	4.00	-0.56	3.00	-0.10	9.00	1.78	5.13	-0.02	8.38**	0.85
$L_1 \times T_3$	20.33	-0.64	4.00	-0.37	2.30	-1.10*	5.00	-1.37	5.34**	0.21**	5.14	-0.51
$L_2 \times T_1$	17.00	-1.27	3.67	0.59	2.67	0.14	6.67	0.03	4.69	-0.24**	6.31	0.52
$L_2 \times T_2$	19.33	1.80	4.00	0.44	3.00	-0.10	6.00	-1.11	5.40**	0.20**	6.04	-0.98*
$L_2 \times T_3$	17.33	-0.53	2.33	-1.03	3.67	0.24	7.33	1.08	5.20	0.04	5.59	-0.46
$L_3 \times T_1$	21.33	1.6	2.00	-0.97	2.33	-1.03	8.67	0.03	5.02	-0.02	6.15	-0.85
$L_3 \times T_2$	19.00	0.02	4.33	0.89	4.00	0.35	10.00	0.89	5.23*	-0.07	9.53**	1.30**
$L_3 \times T_3$	17.67	-1.64	3.33	0.08	4.67	0.68	7.33	-0.92	5.37**	0.09	5.89	-0.45
$L_4 \times T_1$	21.33	1.17	5.67	0.81	3.00	0.19	12.00*	1.81	5.17	0.16**	9.46	2.18**
$L_4 \times T_2$	18.00	-1.42	4.67	-0.67	3.00	-0.10	9.00	-1.67	5.23*	-0.14	6.69	-1.82**
$L_4 \times T_3$	20.00	-0.48	5.00	-0.14	3.33	-0.10	9.67	-0.14	5.13	-0.11**	6.26	-0.36
$L_5 \times T_1$	18.00	-1.21	4.00	0.52	3.67	0.41	8.00	-0.86	4.34	-0.34**	6.82	0.59
$L_5 \times T_2$	20.17	1.69	6.33	1.33	4.00	0.46	9.33	-0.00	5.17	0.22**	6.41	-1.05*
$L_5 \times T_3$	18.33	0.75	4.00	-0.82	3.00	-0.87	9.33	0.86	5.03	0.12*	6.03	0.46
$L_6 \times T_1$	19.00	-8.3	4.00	0.48	3.00	-0.14	8.33	-0.19	5.21	0.19**	5.68	-0.33
$L_6 \times T_2$	19.67	0.08	2.33	-1.67*	2.33	-1.10*	7.33	-1.67	5.03	-0.26**	5.66	-1.57**
$L_6 \times T_3$	20.67	2.30*	5.00	1.19	5.00	1.24*	10.00	1.86	5.33**	0.07	7.24	1.90**
$L_7 \times T_1$	18.00	-2.10*	3.00	-1.30	2.00	-0.48	7.67	-0.41	5.45	0.44**	6.02	-1.78**
$L_7 \times T_2$	19.17	-0.20	5.00	0.22	3.33	0.57	10.33	1.78	5.25*	-0.02	12.30**	3.27**
$L_7 \times T_3$	22.00	-0.02	5.67	1.08	3.00	-0.10	6.33	-1.37	4.83	-0.42**	5.66	-1.49**

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

In the present study, (Table 3) The hybrids with significant sca effects were found in the crosses RTU-14 × VBN-1 ($L_1 \times T_1$) and N0 30-26 × VBN-5 ($L_7 \times T_3$) for plant height. For number of branches per plant, the hybrids AC-249 × VBN 2 ($L_5 \times T_2$) and H70-3 × VBN-1 ($L_4 \times T_1$) has the significant sca effects. The crosses KMB-1 × VBN-5 ($L_6 \times T_3$) and AKU-98-01 × VBN-5 ($L_3 \times T_3$) had significant sca effects for number of clusters per plant. For number of pods per plant, significant sca effects were observed in the crosses H70-3 × VBN-1 ($L_4 \times T_1$) and NO 30-26 × VBN-2 ($L_7 \times T_2$). The hybrids AC 206 × VBN 2 ($L_2 \times T_2$) and AKU98-01 × VBN-5 ($L_3 \times T_3$) has the high sca values for 100 seed weight. Similarly, the crosses NO 30-26 × VBN-2 ($L_7 \times T_2$) and AKU 98-01 × VBN-2 ($L_3 \times T_2$) has the significant sca effects for seed yield.

CONCLUSION

From the aforementioned investigation and based on significant sca effects, the crosses NO 30-26 × VBN-2 is adjudged as superior hybrids since it contributes high sca values for yield and yield contributing traits.

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