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Genetic analysis of quantitative traits in Blackgram using line x tester design

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Abstract
Blackgram is one of the most important pulse crops. An investigation was carried out in blackgram to understand the gene action and to estimate the general combining ability (GCA) effect of parents and specific combining ability (SCA) effect of 15 crosses (involving five lines and three testers) for yield and its traits using Line x Tester analysis. The relative estimates of variance due to GCA were higher than SCA variances for most of the traits indicating predominance of additive gene action. Among the parents, based on GCA effects, Pant U-30, B-3-8-8 and LBG-787 were found to be good general combiners for yield and its contributing traits and can be used in future breeding programmes. Based on SCA effects, the cross, B-3-8-8 x Vamban 7 was identified as best specific combiner for no.of pods per plant and could be further exploited to obtain transgressive segregants.

Keywords: Blackgram, gene action, general combining ability, line × tester, specific combining ability

Introduction

Blackgram (*Phaseolus mungo* Linn./*Vigna mungo* (L.) Hepper), also known as Urdbean, black maple, *etc*., is a self-pollinated crop with a very low percentage of natural out crossing. It is one of the most important short duration pulse crops in India belonging to Fabaceae family. It has chromosome number 2n = 22 with an estimated genome size of 574 megabase pairs, approximately (Arumuganathan and Earle, 1991) [1]. It is widely consumed in the form of 'Dal' and flour. With elevated lysine content, it complements rice, contributing to well-balanced human nutrition profile. Additionally, blackgram seeds serve as a rich source of phosphoric acid, proteins, and minerals. According to the report by Aykroyd and Doughty (1964), the protein content in blackgram is around 24%, minerals 3.2%, fat 1.4%, carbohydrates 57.3%, and moisture 9.7%.

India serves as the primary centre of origin of blackgram, while Central Asia is considered as the secondary centre of origin (De Candolle, 1882; Vavilov, 1926) [5, 23]. Due to its tropical nature, urdbean cultivation is primarily distributed in Asian and African countries. India stands as the leading producer of urdbean, followed by Myanmar, Thailand, and Pakistan. Notably, India contributes to 70% of the global blackgram production (DA and FW, 2018) [7]. Major growing states are Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Odisha. In India, blackgram is grown over an area of around 3.5 million ha with 1.5 to 1.9 million tonnes of annual production with an average productivity of 500kg per hectare.

The reasons for low productivity may be ascribed to the crop being cultivated on marginal lands and non-availability of high yielding and stable varieties suitable to different ecological situations (Debbarma *et al*. 2022) [6]. Blackgram is not fully exploited as it was totally neglected and has received relatively less attention for all the aspects of genetic studies. It has also been suspected that insufficient variability is the primary reason behind the poor progress made in breeding programs of pulse crops. So, developing high yielding and stable varieties through genetic improvement is the need of the hour where the choice of right type of parents to be incorporated in hybridization programme is a crucial step for the breeder (Konda *et al*. 2009) [11].

Different methods are available for selection of parental lines for hybridization programme, in which Line × Tester analysis developed by Kempthorne (1957) [10] is more precisely used to predict parents general combining ability (GCA) for selecting suitable parents and hybrids that have good specific combining ability (SCA). It also provides information on the nature and magnitude of the gene action that is involved in the inheritance of different characters.

Materials and Methods

The experimental material used in the present investigation consisted of 8 elite genotypes of blackgram in which five genotypes *viz*., OBG-32, B-3-8-8, OBG-33, Ujala, Pant U-30 were used as the Lines (Females) and three genotypes *viz*., LBG-787, Vamban 7, Pant U-31 as Testers (Males). Five lines and three testers were crossed adopting line x tester mating scheme to develop 15 crosses during Rabi 2018-2019. These 15 F_1 crosses along with their parents were grown in a Randomized Block Design with two replications maintaining row to row and plant to plant distance of 30 cm and 10 cm, respectively. Experiment was carried out by conducting the field experiment at College of Agriculture, Bhubaneshwar during Summer 2019. All package of practices were followed to grow a healthy crop and plant protection measures taken up as and when required.

Ten competitive plants were selected randomly from each entry in each replication for recording the observations. The data on ten observations *viz*., Days to 50% flowering (days), Days to maturity (days), Plant height (cm), Number of primary branches per plant, Number of clusters per plant, Number of pods per plant, Pod length (cm), Number of Seeds per pod, 100-Seed Weight (gm), Single plant yield (gm) were recorded on each of the selected plant, except for days to 50% flowering, days to maturity and 100-seed weight for which data was recorded on entry basis. The recorded data were analysed using the method given by Panse and Sukhatme (1961) [12]. The analysis of combining ability was carried out following the method suggested by Kempthorne (1957) [10].

Results and Discussion

The analysis of variance in respect of various traits were carried out and presented in Table 1. The genotypic variance was partitioned into crosses, lines, testers and line x tester interaction. And their mean sum of squares revealed significant differences for most of the characters studied, indicating the presence of substantial amount of genetic variability in the material employed in this study. This will provide better opportunities to the plant breeders in selecting the desirable genotypes. Earlier researchers, such as Kumar *et al*. (2017) [13], also reported similar findings. The components of variance due to GCA of 10 characters in blackgram are presented in the Table 2. Estimated values of general combining and specific combining ability variances for 10 characters showed that GCA variance is higher than SCA variance *i.e*., variance ratio is greater than unity for most of the characters like days to 50% flowering, days to maturity, plant height, no.of clusters per plant, number of pods per plant, pod length, 100-seed weight and single plant yield indicating the preponderance of additive gene effects in the expression of these traits. Similar reportings by Karthikeyan *et al*. (2007) [9], Chakraborty *et al*. (2010) [3], Surashe *et al*. (2017) [19] also reported the importance of additive genetic component in the expression of various traits. For the characters like number of branches per plant and number of seeds per pod, SCA variance made greater contribution indicating predominance of non-additive gene effect in the inheritance of these traits. Earlier studies by Vaithiyalingan *et al*. (2002) [22], Santha and Arulmozhi (2003) [15], Srividhya *et al*. (2005) [18], Selvam and Elangaimannan (2010) [16], Gill *et al*. (2014) [8], Chakraborty *et al*. (2010) [3] and Thamodharan *et al*. (2017) [20] were also in agreement with the involvement of non-additive genetic component in the inheritance of various traits in blackgram.

Table 1: Analysis of variance for combining ability for 10 characters in blackgram

Source	d.f.	Mean sum of squares									
		Days to 50% flowering (days)	Days to maturity (days)	Plant height (cm)	No. of primary branches per plant	No. of clusters per plant	No. of pods per plant	Pod length (cm)	No. of seeds per pod	100-seed Weight (gm)	Single plant yield (gm)
Replication	1	0.349	0.667	4.698	0.947	3.028	1.768	0.136	0.565	0.026	0.811
Crosses	14	2.491*	3.391**	13.142**	0.286	5.438**	71.248**	0.045	0.145	0.032	3.481**
Lines	4	2.525**	3.892**	4.312**	0.111	3.632**	27.886**	0.038*	0.100	0.020	1.971**
Testers	2	0.817	0.417	22.101**	0.202	7.642**	115.186**	0.014	0.056	0.001	4.232**
Line x Tester	8	0.712	0.917**	3.818**	0.144	1.031*	19.603**	0.017	0.063	0.017	1.003**
Error	22	0.424	0.201	0.620	0.107	0.332	2.393	0.013	0.046	0.020	0.252

Table 2: Estimates of general combining and specific combining ability variances for the 10 characters in black gram

Source	Characters									
	Days to 50% flowering (days)	Days to maturity (days)	Plant height (cm)	No. of primary branches per plant	No. of clusters per plant	No. of pods per plant	Pod length (cm)	No. of seeds per pod	100-seed Weight (gm)	Single plant yield (gm)
σ^2_{GCA}	0.6251	0.9918	3.8209	0.0116	2.1892	21.8776	0.0071	0.0122	0.0010	0.9685
σ^2_{SCA}	0.2885	0.7155	3.1985	0.0372	0.6991	17.2099	0.0039	0.0173	0.0000	0.7508
$\sigma^2_{GCA} / \sigma^2_{SCA}$	2.1667	1.3861	1.1946	0.3118	3.1314	1.2712	1.8205	0.7052	-	1.2899
$h^2_{(bs)}$ (%)	68.30	89.47	91.88	31.34	89.69	94.23	45.84	39.01	4.56	87.22

Thangavel *et al*. (2004) [21], Karthikeyan *et al*. (2007) [9], Ram *et al*. (2013) [14], Shalini and Lal (2019) [17], and Bharathi *et al*. (2019) [2] had previously reported the involvement of both additive and non-additive genetic components in the expression of different traits in blackgram.

The GCA effects of the parents is presented in Table 3. Among five lines and three testers, none of the parents were found to be good general combiners for all the traits under consideration. Among the lines, OBG-32 and B-3-8-8 were found to be good general combiners for days to 50% flowering and days to maturity with significant negative GCA effect as early flowering is preferable here. Similarly, the line OBG-33 was found to be good general combiner for plant height with significant negative GCA effect. The line B-3-8-8 was found to be a good general combiner for no. of clusters per plant, no. of pods per plant and single plant yield with highly significant positive GCA effects. Line Pant U-30 was observed to be having significant positive GCA effects for no. of pods per plant and single plant yield, and can be used as a good general combiner for those traits. Among the testers, LBG-787 was found to be a good general combiner for no. of clusters per plant, no. of pods per plant and single plant yield with significant positive GCA effects, while Pant U-31 was found to be a good general combiner for plant height with significant negative GCA effect.

Overall, the lines Pant U-30, B-3-8-8 and tester LBG-787 were recorded as good general combiners for single plant yield and few other yield contributing traits and can be used in breeding programmes.

Table 3: Estimates of general combining ability (GCA) effects of the 5 females and 3 male parents for 10 characters in black gram

Parents	Characters									
	Days to 50% flowering (days)	Days to maturity (days)	Plant height (cm)	No. of primary branches per plant	No. of clusters per plant	No. of pods per plant	Pod length (cm)	No. of seeds per pod	100-seed Weight (gm)	Single plant yield (gm)
Female parents										
OBG-32	-1.067*	-1.467**	-0.003	0.100	-0.680	-2.283*	-0.093	-0.113	-0.069	-0.620
B-3-8-8	-0.900*	-0.967**	0.813	0.000	1.537**	3.883**	0.057	0.137	0.053	1.347**
0BG-33	0.433	1.033**	-2.070*	-0.183	-0.313	-2.050*	-0.143	-0.230	-0.046	-0.920**
Ujala	0.933*	0.867**	0.563	-0.183	-1.213**	-2.283*	0.123	0.220	0.044	-0.053
Pant U-30	0.600	0.533	0.697	0.267	0.670	2.733*	0.057	-0.013	0.124	1.047**
S.E. (g_i) female	0.412	0.284	0.498	0.207	0.364	0.978	0.072	0.136	0.089	0.317
Male parents										
LBG-787	0.067	0.167	1.153**	0.223	1.423 **	5.337**	0.020	0.017	-0.015	0.970**
Vamban 7	0.367	0.167	1.273**	-0.057	-0.617	-1.373	0.040	0.097	0.007	-0.110
Pant U-31	-0.433	-0.333	-2.427**	-0.167	-0.807*	-3.963**	-0.060	-0.113	0.007	-0.860**
S.E. (g_i) male	0.336	0.232	0.407	0.169	0.298	0.799	0.059	0.111	0.073	0.259

Table 4: Estimates of specific combining ability (SCA) effects for 10 characters in black gram

Sl. No.	Crosses	Characters									
		Days to 50% flowering (days)	Days to maturity (days)	Plant height (cm)	No. of primary branches per plant	No. of clusters per plant	No. of pods per plant	Pod length (cm)	No. of seeds per pod	100-seed Weight (gm)	Single plant yield (gm)
1.	OBG-32 x LBG-787	0.767	1.167	0.063	-0.190	-0.090	2.613	0.013	0.083	-0.079	1.280
2.	x Vamban 7	-0.533	-1.333*	-0.557	-0.210	-0.450	-0.627	-0.057	-0.147	-0.041	-0.340
3.	x Pant U-31	-0.233	0.167	0.493	0.400	0.540	-1.987	0.043	0.063	0.119	-0.940
4.	B-3-8-8 x LBG-787	-0.900	-0.833	-2.153*	-0.340	-1.207	-5.503*	0.113	0.183	0.055	-1.237
5.	x Vamban 7	0.300	0.667	1.427	-0.060	1.133	7.807**	0.043	0.003	-0.117	1.543
6.	x Pant U-31	0.600	0.167	0.727	0.400	0.073	-2.303	-0.157	-0.187	0.063	-0.307
7.	OBG-33 x LBG-787	0.267	-0.333	-1.520	0.093	0.343	-0.070	-0.037	-0.050	0.128	-0.220
8.	x Vamban 7	0.467	0.667	0.310	0.273	0.833	0.140	-0.157	-0.280	0.036	-0.340
9.	x Pant U-31	-0.733	-0.333	1.210	-0.367	-1.177	-0.070	0.193	0.330	-0.164	0.560
10.	Ujala x LBG-787	0.267	-0.167	1.547	0.443	0.593	2.913	-0.053	-0.150	-0.142	0.363
11.	x Vamban 7	0.467	0.833	-1.923	0.023	-0.317	-3.627	0.127	0.370	0.166	-0.457
12.	x Pant U-31	-0.733	-0.667	0.377	-0.467	-0.277	0.713	-0.073	-0.220	-0.024	0.093
13.	Pant U-30 x LBG-787	-0.400	0.167	2.063	-0.007	0.360	0.047	-0.037	-0.067	0.038	-0.187
14.	x Vamban 7	-0.700	-0.833	0.743	-0.027	-1.200	-3.693	0.043	0.053	-0.044	-0.407
15.	x Pant U-31	1.100	0.667	-2.807**	0.033	0.840	3.647	-0.007	0.013	0.006	0.593
	S.E.(g_{ij})	0.824	0.567	0.996	0.414	0.729	1.957	0.144	0.271	0.179	0.635

Estimates on SCA effects (Table 4) revealed that out of 15 crosses, OBG-32 x Vamban 7 exhibited significant negative SCA effect for days to maturity, indicating the possibility for the development of blackgram varieties with early maturity. Beside this, two crosses *viz.*, B-3-8-8 x LBG-787 and Pant U-30 x Pant U-31 exhibited significant negative SCA effect for plant height, indicating the possibility for the development of short stature blackgram varieties. One cross, B-3-8-8 x Vamban 7 exhibited significant positive SCA effect for no. of pods per plant. Debbarma *et al.* 2020 [6] had previously reported crosses exhibiting significant positive SCA effect for no. of pods per plant. None of the crosses recorded significant positive SCA effects for no. of primary branches per plant, no. of clusters per plant, pod length, no. of seeds per pod, 100-seed weight, single plant yield.

Conclusion

The variance due to GCA was higher than variance due to SCA in most of the traits like days to 50% flowering, days to maturity, plant height, no. of clusters per plant, number of pods per plant, pod length, 100-seed weight and single plant yield, which indicates the predominance of additive gene effect in the expression these traits. Therefore, hybridization followed by simple selection would be rewarding. For traits like number of primary branches per plant and number of seeds per pod, SCA variance was found to be higher than GCA variance indicating the preponderance of non-additive gene action. Heterosis breeding could be effectively utilized for these traits. Among parents, Pant U-30, B-3-8-8 and LBG-787 were found to be good general combiners showing significant GCA effect in desirable direction for single plant yield and few other yield contributing traits. These genotypes could be used to develop pure line varieties. B-3-8-8 x Vamban 7 recorded significant positive SCA effect for no. of pods per plant and could be used in future breeding programmes.

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