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Studies on combining ability for yield and its attributes in black gram (*Vigna mungo* L. Hepper)

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Abstract
Fifteen F1 hybrids were produced in line x tester design with five lines and three testers in blackgram (*Vigna mungo* (L.) Hepper) to understand the nature of gene action, combining ability of the parents (GCA) and to assess the potential for the exploitation of heterosis (SCA) in hybrids. Among the genotypes, T9, LBG-20, IPU2-3 and MASH 1008 recorded significant positive GCA effects for seed yield. The hybrid, T-9X MASH1008, PU-31X MASH1008, PU-31X IPU-2-43 followed by LBG-20X PU-11-14 exhibited significant positive SCA for seed yield (kg/ha). The crosses recorded significant positive SCA effects for most of the characters inferring that these crosses would produce superior recombinants for seed yield.

Keywords: Line × tester, seed yield, yield attributes, GCA, SCA, heterosis, blackgram and SAT

Introduction
Black gram or urd bean is an important pulse crop of the tropics and semi-arid tropics and has been identified as a potential crop in many countries (Girish *et al*., 2012) [3]. It is an important pulse crop of India and is mainly cultivated as a source of dietary protein because of its high protein content which is of about 25% in seeds (Haytowitz and Mathews, 1986) [6]. Being a legume crop it can potentially fix about 80% of its own nitrogen needs through biological nitrogen fixation and in addition can contribute to the yield of subsequent crops. The yield of this crop is stagnated over two decades and significant seasonal as well as year to year variation in yield was recorded due to non-availability of high yielding and stable performing cultivars. In order to increase the production and productivity of black gram it is essential to develop a high yielding pure line variety by selection from the segregating generations of superior crosses involving superior parents.

Materials and Methods
The experimental material for present investigation was carried out during *rabi*, 2019-20 at Agricultural research station, Podalakur, Nellore district. Data on seven quantitative characters *viz.*, days to 50 per cent flowering, plant height (cm), number of clusters per plant, number of pods per plant, days to Maturity, hundred seed weight (g) and seed yield (kg/ha) were collected on 15 hybrids and their 8 parents.
Eight lines *viz.*, LBG-750, T-9, PU-31, LBG-685, LBG-20 and three testers *viz.*, PU-11-14, MASH1008, IPU-2-43 were used as parents and crosses were effected in L x T fashion at Agricultural research station, Podalakur during *rabi*, 2018-19. The fifteen hybrids evaluated in RBD with two replications adopting a spacing of 30 cm x 10 cm during *rabi*, 2019-20. Recommended agronomical practices were adopted to raise the crop. Biometrical observations were taken on 10 randomly selected plants in each replication for seven quantitative traits. Analysis of data for general and specific combining ability effects and variances was estimated by following the procedure of Line x Tester analysis given by Kempthorne (1957) [8].

Results and Discussion
The ANOVA revealed that mean squares due to genotypes, parents, crosses, lines, testers and lines x testers were highly significant for the traits (Table 1) under evaluation connoting the existence of wider genetic diversity among the lines, testers and hybrids. The ratio of GCA to SCA variance was less than unity for all the traits studied, indicating the preponderance of non-additive gene action governing the traits. Similar results were reported by Seenaiah *et al.* (1993) [9], Govindraj and Subramanian (2001) [4] and Anbu Selvam and Elangaimannan (2010) [1], Isha Parveen *et al.* (2012) [7] and Vijay Kumar *et al.* (2014). The success of any breeding programme largely depends on the choice of parents used in the hybridization. Gilbert (1958) [2] suggested that the parents with good *per se* performance would result in better hybrids.

The GCA effect is a good estimate of additive gene action (Sprague and Tatum, 1942) [10]. The general combining ability effects of parents for different traits are presented in Table 2. Among the genotypes studied, no entry had manifested good general combining ability for all the quantitative traits. However, good combiners identified for high seed yield (kg/ha) are T9, LBG-20, IPU2-3 and MASH 1008. For early maturity, the line PU 31 was identified to be good general combiner. The line LBG-685, LBG-20 and the tester IPU-2-43was also found to be best general combiner for short plant stature. For the trait, number of clusters per plant, the line, LBG-20 were good general combiner. Hence, involvement of these genotypes in the crossing programme would result in the identification of superior segregants with favorable genes for seed yield and its attributes.

The specific combining ability (SCA) effects of the 15 F1 crosses for seven quantitative traits were computed (Table. 3). SCA is the deviation from the performance predicted on the basis of general combining ability (Allard, 1956) [12]. High SCA effect alone may not be the appropriate choice of the hybrid for heterosis exploitation because the hybrids with low mean value may also possess high SCA effects, even if the GCA effects of the parents were very low or even negative (Grakh and Chaudhary, 1985) [5]. Being a self-pollinated crop, it is not possible to exploit heterosis, however it may be utilized if any new method or male sterility is identified in blackgram in future. The crosses involving the parents, T-9 X MASH1008, LBG-685 X MASH1008 and LBG-20 X PU-11-14 recorded significant positive SCA effect for days to maturity and the crosses PU-31 X MASH1008, LBG-20 X PU-11-14, PU-31 X IPU-2-43 and T-9 X MASH1008 for seed yield (kg/ha). The presence of highly significant GCA and non-significant SCA may be due to additive and additive x additive interaction. Hence, these crosses may be utilized for recombination breeding for further exploitation as these hybrids would throw segregants for high seed yield (kg/ha) in combination with early maturity. However the ratio of GCA/SCA variance indicated the preponderance of non-additive gene action and hence, selection could be postponed to later generations.

Table 1: Analysis of variance for combining ability in Black gram for yield and its components

Source	**df**	**DFF**	**DM**	**PH**	**CP**	**PP**	**SY**	**HSW**
Replication	1	4.03*	14.70*	255.21*	1.32*	58.80*	172.80*	0.012*
Genotype	22	10.38*	19.67*	41.96*	4.50*	16.53*	7343.57*	0.15*
Parent	7	9.71*	17.42*	22.92*	1.13*	11.68*	2711.10*	0.21*
Crosses	14	2.76*	8.70*	25.47*	2.57*	17.18*	7571.85*	0.11*
Parents v/s crosses	1	121.82*	188.85*	406.22*	54.98*	41.40*	36575.30*	0.18*
Lines	4	6.67*	3.72*	18.85*	3.13*	11.28*	16921.80*	0.01*
Testers	2	1.73*	3.23*	7.42*	1.07*	32.033*	1192.53*	0.07*
Lines x Testers	8	1.07*	12.57*	33.29*	2.67*	16.41*	4491.70*	0.18*
Error	14	1.82	2.48	35.48	3.56	25.30	3649.66	0.05

* Significant at 5% level
** Significant at 1% level
DFF - Days to 50% Flowering DM – Days to Maturity
PH Plant Height (cm) CP – No of clusters per plant
PP – No of pods per plant SY – Seed Yield (kg/ha)
HSW – 100 seed weight (g)

Table 2: General Combining ability effects of parents for different traits in Black gram

Parents	**DFF**	**DM**	**PH**	**CP**	**PP**	**SY**	**HSW**
Lines							
LBG-750	0.17	-0.73	-2.66	0.34	0.30	12.07	-0.04
T-9	0.83	-0.07	0.08	-0.68	-1.53	83.43*	0.06
PU-31	-1.17	1.27*	-0.49	-0.81	2.13*	19.57	-0.01
LBG-685	-1.00	0.10	1.014*	0.26	-0.70	-9.10	-0.04
LBG-20	1.17	-0.57	2.06*	1.89*	-0.20	60.90*	0.04
SE	0.55	0.64	1.43	0.77	2.05	24.6	0.094
Testers							
PU-11-14	-0.47	-0.17	-0.41	0.34	-2.07	-7.47	-0.09
IPU-2-43	0.33	0.63	1.99*	-0.31	1.03	12.53*	0.00
MASH1008	0.13	-0.47	-0.58	-0.04	1.03	5.07*	0.08
SE	0.42	0.49	1.88	0.59	1.59	19.10	0.07

* Significant at 5% level

Table 3: Species combining ability effects of hybrids for different traits in Black gram

Hybrids	**DFF**	**DM**	**PH**	**CP**	**PP**	**SY**	**HSW**
LBG-750X PU-11-14	0.13	-0.67	-1.42	0.04	-0.60	15.63	-0.20
LBG-750X IPU-2-43	-0.67	0.53	3.98	0.84	1.80	-22.37	-0.04
LBG-750X MASH1008	0.53	0.13	-2.55	-0.88	-1.20	6.73	0.23
T-9X PU-11-14	-0.03	-1.33	-0.66	-0.44	1.23	-10.87	0.00
T-9X IPU-2-43	0.17	-0.13	-3.16	-0.49	-0.37	-16.37	0.21
T-9X MASH1008	-0.13	1.47*	3.81	0.94	-0.87	27.23*	-0.22
PU-31X PU-11-14	0.97	1.33	-0.19	-0.11	3.07	-69.37	-0.13
PU-31X IPU-2-43	-0.83	1.03	-4.59	-0.06	-3.53	41.63*	0.38*
PU-31X MASH1008	-0.13	-2.37	4.78	0.17	0.47	27.73*	-0.25

LBG-685X PU-11-14	-0.20	-3.00	2.11	1.22	0.90	3.80	0.05
LBG-685X IPU-2-43	0.50	0.20	2.91	0.47	-1.20	-11.20	-0.14
LBG-685X MASH1008	-0.30	2.80*	-5.02	-1.70	0.30	7.40	0.08
LBG-20X PU-11-14	-0.87	3.67**	0.16	-0.71	-4.60	60.80*	0.27
LBG-20X IPU-2-43	0.83	-1.63	0.86	-0.76	3.30	8.30	-0.42*
LBG-20X MASH1008	0.03	-2.03	-1.02	1.47	1.30	-69.10	0.15
SE	0.95	1.11	4.21	1.33	3.56	22.72	0.16

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