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# HETEROSIS AND GENETIC VARIABILITY FOR YIELD RELATED ATTRIBUTES IN BLACKGRAM (*Vigna mungo* (L.) Hepper)

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**ABSTRACT**
The present investigation was carried out with a view to study the magnitude of genetic variability and heterosis parameters excluding reciprocals involving 15 parents and their 21 F1 in black gram and 2 checks (T-9 and AZAD-1) and were evaluated during *kharif* -2017 in randomized block design with three replications at the field experimentation Centre, Department of Genetics and Plant Breeding, SHUATS, Allahabad, U.P. The analysis of variance for all the characters revealed that parents were found to be highly significant for all the characters except number of clusters per plant, number of seeds per pod and pod length. Hybrids were highly significant at 5%, 1% level and all the characters, indicating presence of considerable amount of genetic variability in the parental material tested. Parents vs. Hybrids comparison were found to be highly significant for all the characters except number of seeds per pod, pod length and 100 seed weight. A perusal of genetic parameters revealed that GCV, PCV, heritability and Genetic Advance as per cent of Mean were high for the characters *viz*., biological yield, number of pods per plant, seed yield per plant, harvest index, numbers of clusters per plant, number of primary branches per plant and plant height. Magnitude of heterosis, heterobeltiosis and standard heterosis was observed for almost all the characters. The cross combinations, LBG-20 X LBG-791, VALLABH URD X PU-38 and LBG-20 X KU-96-7 registered highest significant heterosis, heterobeltiosis and standard heterosis for seed yield per plant so they should be given prime importance for future breeding programme.

**KEYWORDS:** Blackgram (*Vigna mungo*), Heritability, Genetic Advance, Variation, Heterosis.

## INTRODUCTION

Blackgram (*Vigna mungo* (L.) Hepper) popularly known as urdbean or mash, is a grain legume domesticated from *V. mungo var. silvestris* (Lukoki, 1980). It belongs to family leguminosae with chromosome number 2n = 2x = 22. Blackgram is reported to be originated in India (Zukovskiji, 1962). It is a cheap source of dietary protein (24%). It also contributes 76% carbohydrate 3-5% Fiber, 1.74% Fat and a major portion of lysine in the vegetarian diet. It is the richest sources of phosphoric acid. Being 5-10 times richer than other crops. Besides, being used as food for inexpensive source of dietary protein it is better to use for bean sprouts than mungbean for its longer self-life (Khan *et al.,* 2001).

Heterosis term was first used by Shull in 1914. Heterosis may be defined as the superiority of F1 hybrid over its parents in terms of yield or some other character. More generally, Heterosis is estimated over the superior plant.

The presence of Heterosis in food legumes has also been demonstrated by Srivastava *et al*.(2012). Little information about Heterosis and gene action is available in blackgram. The exploitation of heterosis in urdbean has not been commercialized due to limited extent of out crossing (Singh, 2000). However, highly heterotic crosses can be used for development of high yielding pure line varieties in a self-pollinated crop like urdbean. Genetic improvement mainly depends upon the amount of genetic variability present in the base population (Krishnan *et al*., 2012). Among the legumes urdbean is one of the narrow genetic base crop represents smaller variability in primary gene pool. Lack of newer varieties and genotypes adapted to local environment is among the factors affecting its production necessitating, the development of new varieties adapted to local condition. Heterosis has important implications for both in F1 and for adopting transgressive segregates in $F_2$ generation (Ram *et al*., 2013).

Besides the major constrains in achieving higher yield of black gram is absence of suitable ideotypes for different cropping. The creation of variability is difficult through hybridization due to its high self-pollination and flower droop system, poor harvest index and susceptibility to disease (Krishnan *et al.,* 2004). Therefore genetic variability is the basic requirement for making progress in crop breeding (Reddy *et al.,* 2004).

## MATERIALS & METHODS

The present investigation was carried out for 13 characters of blackgram (*Vigna mungo* (L.) Hepper) and the experimental materials constituted of the germplasm collection of 38 genotypes (15 parents, 21 hybrids and 2 checks) among the parents *viz.,* PU-11-14, NDUK-13-6, LBG-11, LBG-791, PU-38, PU-31, VALLABH URD, L-6, MASH-338, KU-96-7, MU-44, NDUK-13-4, LBG-20, T-4 and KPU-63-189. Among the checks *viz.,* T-9 and AZAD-1. The experiment was conducted in *kharif* (2017) at the Field Experimentation Centre, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture Technology & Sciences,

Allahabad (U.P). Five plants were selected at random and biometrical observations like, days to 50% flowering, days to 50% pod setting, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per plant, number of seeds per pod, pod length (cm), 100 seed weight (g), biological yield (g), harvest index (100%) and seed yield per plant (g) were recorded on plot basis. Standard statistical procedure were used for the genetic variability (GCV & PCV) by Burton (1952), heritability described by Burton and Devane (1953), genetic advance suggested by Johnson *et al.*,(1955) and the mean data on above traits were used to compute relative heterosis (Ha), heterobeltiosis (Hb) described by Fonseca and Patterson (1968) & economic heterosis suggested by Meredith and Bridge (1972).

## RESULTS & DISCUSSION

### Analysis of variance

The analysis of variance for all the characters (Table 1) revealed that parents were found to be highly significant for all the characters except number of clusters per plant, number of seeds per pod and pod length. Hybrids were highly significant at 5%, 1% level and all the characters, indicating presence of considerable amount of genetic variability in the parental material tested. Parents vs. Hybrids comparison were found to be highly significant for all the characters except number of seeds per pod, pod length and 100 seed weight.

## GENETIC VARIABILITY

### Genotypic coefficient of variation

The GCV was high for biological yield per plant (37.57%) followed by pods per plant (32.06%), seed yield per plant (28.53 %) and harvest index (26.05%). The GCV was moderate for number of clusters per plant (19.12%), primary branches per plant (14.53%), and plant height (12.53%). The GCV was low for rest of the characters like days to 50 % flowering (9.42%), 100 seed weight (9.20%), days to 50 % pod setting (8.59%), and number of seeds per pod (5.71%), pod length (5.60%) and days to maturity (4.53%). The studies on genotypic coefficient of variation indicates the magnitude of GCV was highest in case of biological yield, seed yield per plant, harvest index, number of primary branches per plant, plant height indicating of high amount of variation in these traits. Similar results are reported by Veeramani *et al*. (2005); Govindarasu *et al*., (2010); Meshram *et al*. (2012) for plant height and seed yield per plant Gowsalya *et al*. (2016).

### Phenotypic coefficient of variation

The PCV was high for biological yield (38.80%) followed by, number of pods per plant (34.67%), seed yield per plant (29.69%), harvest index (29.03%) and number of cluster per plant (27.08%). The PCV was moderate for primary branches per plant (16.63%) followed by, plant height (13.84%), 100 seed weight (13.36%), number of seeds per pod (12.32%) and days to 50% flowering (10.02%). The PCV was low for rest of the characters like days to 50% pod setting (9.52%), pod length (9.33%), days to maturity (5.38%). The studies on phenotypic coefficient of variation indicates the magnitude of PCV was highest in case of biological yield, harvest index, seed yield per plant, number of primary branches per plant, number of pods per plant, plant height indicating the presence of high amount of variation in these traits. Similar results are reported by Singh *et al.* (2016) observed similar results in blackgram.

### Heritability and Genetic Advance

High heritability values coupled with high genetic advance as percent of mean showing high to high heritability estimates were observed for the characters *viz.,* biological yield (93.00%, 96.05%), seed yield per plant (92.00%, 72.36%), days to 50% flowering (88.00%, 23.41%), number of pods per plant (85.00%, 78.27%), plant height (82.00%, 29.98%), days to 50% pod setting (81.00%, 20.49%), harvest index (80.00%, 61.74%) and number of primary branches per plant (75.00%, 33.08%). Heritability estimates along with genetic advance are normally more useful in predicting the gain under selection than that of heritability alone. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance (Johnson *et al*., 1955).

### Heterosis, Heterobeltiosis and Standard heterosis

**Heterosis:** The heterosis of the crosses revealed that the cross VALLABH URD X KU-96-7 displayed high significant negative heterosis for days to 50% flowering whereas LBG-791 X NDUK-13-6 for days to 50% pod setting, VALLABH URD X PU-38 for days to maturity and LBG-791 X NDUK-13-4 for plant height followed by high significant positive heterosis for LBG-791 X T-4 for primary branches per plant, LBG-791 X NDUK-13-4 for clusters per plant, LBG-791 X T-4 for pods per plant, VALLABH URD X PU-31 for seeds per pod, LBG-20 X KU-96-7 for pod length, LBG-791 X NDUK-13-6 for 100 seed weight, VALLABH URD X MU-44 for biological yield, LBG-791 X VALLABH URD for harvest index and LBG-20 X LBG-791 for seed yield per plant.

**Heterobeltiosis:** The heterobeltiosis of the crosses revealed that the cross VALLABH URD X KU-96-7 displayed high significant negative heterobeltiosis for days to 50% flowering whereas LBG-791 X NDUK-13-6 for days to 50% pod setting, VALLABH URD X PU-38 for days to 50% maturity and LBG-791 X NDUK-13-4 for plant height followed by high significant positive heterobeltiosis for LBG-791 X T-4 for primary branches per plant, LBG-791 X NDUK-13-4 for clusters per plant, VALLABH URD X T-4 for number of pods per plant, VALLABH URD X PU-31 for number of seeds per pod, LBG-20 X KU-96-7 for pod length, LBG-791 X NDUK-13-6 for 100 seed weight, LBG-20 X VALLABH URD for biological yield, PU-11-14 X KPU-63-189 for harvest index and LBG-20 X LBG-791for seed yield per plant.

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**TABLE 1:** Analysis of variance for 13 quantitative characters in Blackgram

| S. No | Character | Replication d.f=2 | Treatment d.f=37 | Hybrids d.f=21 | Parents d.f=15 | Hybrids vs. Parents | Checks | Checks vs. Hybrids | Checks vs. Parents | Error | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Days to 50% flowering | 1.53 | 45.49** | 25.21** | 29.18** | 582.60** | 0.66 | 78.18** | 381.50** | 1.88 | 16.15 |
| 2. | Days to 50% pods setting | 12.74* | 55.77** | 48.33** | 21.53** | 564.69** | 0.66 | 107.44** | 435.20** | 3.90 | 21.04 |
| 3. | Days to maturity | 0.02 | 32.68** | 38.27** | 19.40** | 166.35** | 0.66 | 0.04 | 31.05** | 3.90 | 13.26 |
| 4. | Plant height | 2.00 | 174.45** | 234.08** | 31.71** | 1075.40** | 6.82 | 469.15** | 43.09 | 11.86 | 64.92 |
| 5. | Number of primary branches per plant | 0.02 | 0.66** | 0.36** | 0.28** | 13.10** | 0.06 | 0.01 | 2.24** | 0.06 | 0.26 |
| 6. | Number of clusters per plant | 2.07 | 51.02** | 36.98** | 22.30 | 833.73** | 1.70 | 24.00 | 66.42* | 12.81 | 25.13 |
| 7. | Number of pods per plant | 64.05 | 404.01** | 418.86** | 140.40** | 2096.69** | 511.15** | 1236.39** | 3039.31** | 21.60 | 147.56 |
| 8. | Number of seeds per pod | 0.50 | 0.84* | 1.13** | 0.56 | 0.55 | 0.16 | 0.09 | 0.01 | 0.46 | 0.58 |
| 9. | Pod length | 0.11 | 0.25** | 0.32** | 0.12 | 0.25 | 0.01 | 0.66** | 0.05** | 0.09 | 0.14 |
| 10. | 100 Seed weight | 0.25 | 0.51** | 0.28* | 0.94** | 0.03 | 0.01 | 0.01 | 0.01 | 0.13 | 0.26 |
| 11. | Biological yield | 21.64 | 341.60** | 271.69** | 85.80** | 5856.41** | 27.73 | 641.72** | 89.58** | 7.40 | 117.08 |
| 12. | Harvest index | 22.25 | 140.79** | 148.10** | 75.94** | 1016.71** | 16.69 | 328.43** | 12.21 | 10.51 | 53.37 |
| 13. | Seed yield per plant | 0.02 | 10.75** | 12.92** | 2.28** | 104.92** | 0.38 | 0.28 | 16.59** | 0.29 | 3.71 |

** and * Significant at 1% and 5% level of significance respectively

**TABLE 1.1:** Genetic parameters for 13 characters of 38 Blackgram genotypes

| S. No | Character | Genotypic Coefficient of variation (%) | Phenotypic Coefficient of variation (%) | Heritability ($h^2$) (%) (broad sense) | Genetic advance | Genetic advance as per cent of mean (5%) |
|---|---|---|---|---|---|---|
| 1. | Days to 50% flowering | 9.42 | 10.02 | 88 | 18.27 | 23.41 |
| 2. | Days to 50% Pods Setting | 8.59 | 9.52 | 81 | 15.99 | 20.49 |
| 3. | Days to maturity | 4.53 | 5.38 | 71 | 7.88 | 10.09 |
| 4. | Plant height | 12.53 | 13.84 | 82 | 23.39 | 29.98 |
| 5. | Number of Primary branches per plant | 14.43 | 16.63 | 75 | 25.81 | 33.08 |
| 6. | Number of Clusters per plant | 19.12 | 27.08 | 49 | 27.82 | 35.65 |
| 7. | Number of Pods per plant | 32.06 | 34.67 | 85 | 61.08 | 78.27 |
| 8. | Number of Seeds per pod | 5.71 | 12.32 | 21 | 5.45 | 6.99 |
| 9. | Pod length | 5.60 | 9.33 | 36 | 6.94 | 8.90 |
| 10. | 100-seed weight | 9.20 | 13.36 | 47 | 13.06 | 16.74 |
| 11. | Biological yield | 37.57 | 38.80 | 93 | 74.95 | 96.05 |
| 12. | Harvest index | 26.05 | 29.03 | 80 | 48.16 | 61.72 |
| 13. | Seed yield per plant | 28.53 | 29.69 | 92 | 56.56 | 72.36 |

**TABLE 1.2 (a)** Heterosis, heterobeltiosis and standard heterosis for 13 characters of 21 Blackgram genotypes

| S.No | | Days to 50% flowering | | | Days to 50% pod setting | | | Plant height | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Genotypes | Ha | Hb | Hc | Ha | Hb | Hc | Ha | Hb | Hc |
| 1. | SHUATS URD 73- PU-11-14 X KU-96-7 | -14.62** | -17.78** | -24.49** | -13.22** | -13.51** | -25.15** | 9.28 | 2.67 | -6.42 |
| 2. | SHUATS URD 74- PU-11-14 X KPU-63-189 | 2.27 | 0.01 | -8.16** | -4.38 | -4.70 | -16.96** | -9.01 | -17.14** | -19.16** |
| 3. | SHUATS URD 75- PU-11-14 X NDUK-13-6 | -17.78** | -17.78** | -24.49** | -10.96** | -12.42** | -21.64** | 40.12** | 28.46** | 23.48** |
| 4. | SHUATS URD 76- PU-11-14 x LBG-11 | -18.01** | -20.74** | -27.21** | -14.01** | -18.67** | -21.05** | 22.96** | 14.56** | 6.31 |
| 5. | SHUATS URD 77- VALLABH URD x LBG-7 | -16.08** | -19.55** | -27.21** | -14.10** | -16.56** | -23.39** | 17.93** | 12.39* | 8.53 |
| 6. | SHUATS URD 78- VALLABH URD x PU-38 | 5.13* | 0.82 | -16.33** | -10.26** | -10.83** | -18.13** | 21.64** | 20.25** | 5.20 |
| 7. | SHUATS URD 79- VALLABH URD x T-4 | -9.68** | -11.11** | -23.81** | -19.87** | -20.38** | -26.90** | 37.80** | 32.94** | 25.14** |
| 8. | SHUATS URD 80- VALLABH URD x L-6 | -3.56 | -6.87 | -17.01** | -22.15** | -22.64** | -28.07** | 15.77** | 8.53 | 8.53 |
| 9. | SHUATS URD 81- VALLABH URD x MASH-338 | -14.61** | -21.38** | -22.45** | -19.75** | -20.99** | -25.15** | -22.73** | -24.05** | -33.55** |
| 10. | SHUATS URD 82- VALLABH URD x KU-96-7 | -5.26* | -6.40* | -20.41** | -12.50** | -15.29** | -22.22** | 10.97* | 8.75 | -0.89 |
| 11. | SHUATS URD 83- VALLABH URD x MU-44 | -15.24** | -22.45** | -22.45** | 4.67 | 0.01 | -8.19** | 8.14 | 5.07 | -2.55 |
| 12. | SHUATS URD 84- VALLABH URD x NDUK-13-6 | -15.95** | -20.00** | -26.53** | 1.29 | 0.01 | -8.19** | 7.96 | 3.11 | -0.89 |
| 13. | SHUATS URD 85- VALLABH URD x PU-31 | -9.68** | -11.11** | -23.81** | 1.00 | -3.18 | -11.11** | 17.36** | 14.60** | 5.20 |
| 14. | SHUATS URD 86- LBG -20 x LBG-791 | -21.45** | -23.94** | -26.53** | 3.29 | 0.64 | -8.19** | 22.59** | 20.41** | 16.28** |
| 15. | SHUATS URD 87- LBG-20 x VALLABH URD | -18.18** | -23.13** | -26.53** | -7.99** | -8.28** | -15.79** | 28.76** | 24.85** | 16.28** |
| 16. | SHUATS URD 88- LBG-20 x KU-96-7 | 4.12 | -2.11 | -5.44* | -6.93* | -9.62** | -17.54** | 22.72** | 21.40** | 13.07** |
| 17. | SHUATS URD 89- LBG-791 x VALLABH URD | -9.80** | -13.53** | -21.77** | -14.75** | -17.20** | -23.98** | -1.32 | -5.96 | -9.19 |
| 18. | SHUATS URD 90- LBG-791 x NDUK-13-6 | -9.70** | -10.37** | -17.69** | -6.31* | -7.84* | -17.54** | 11.49** | 11.24* | 7.42 |
| 19. | SHUATS URD 91- LBG-791 x T-4 | -8.88** | -11.28** | -19.73** | 9.57** | 7.10* | -2.92 | 20.91** | 19.38** | 15.28** |
| 20. | SHUATS URD 92- LBG-791 x NDUK-13-4 | -3.13 | -6.77** | -15.65** | -15.99** | -21.64** | -21.64** | -15.51** | -16.28** | -19.16** |
| 21. | SHUATS URD 93- LBG-791 x PU-31 | -9.65** | -12.03** | -20.41** | 1.37 | 0.01 | -13.45** | -0.06 | -2.52 | -5.87 |

** and * Significant at 1% and 5% level of significance respectively

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**TABLE 1.2 (b)** Heterosis, heterobeltiosis and standard heterosis for 13 characters of 21 Blackgram genotypes

| S.No | Genotypes | No. of primary branches/plant | | | No. of Clusters/Plant | | | No. of Pods/plant | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ha | Hb | Hc | Ha | Hb | Hc | Ha | Hb | Hc |
| 1. | SHUATS URD 73- PU-11-14 X KU-96-7 | 13.94* | 5.62 | 4.44 | 25.14 | 23.96 | 16.70 | 26.15* | 3.35 | -31.16** |
| 2. | SHUATS URD 74- PU-11-14 X KPU-63-189 | 22.16** | 14.61** | 13.33 | 54.39** | 33.46 | 23.27 | 16.41 | -17.04** | -17.04* |
| 3. | SHUATS URD 75- PU-11-14 X NDUK-13-6 | 32.95** | 29.21** | 27.78** | 12.81 | 10.52 | 6.39 | 69.72** | 49.27** | -16.36* |
| 4. | SHUATS URD 76- PU-11-14 x LBG-11 | 13.97* | 13.33 | 13.33 | 19.48 | 15.00 | 6.22 | 67.51** | 61.21** | -25.86** |
| 5. | SHUATS URD 77- VALLABH URD x LBG-7 | 33.33** | 28.57** | 20.00** | 30.48 | 29.44 | 14.72 | 81.57** | 72.13** | 8.94 |
| 6. | SHUATS URD 78- VALLABH URD x PU-38 | 42.50** | 39.02** | 26.67** | 9.18 | 8.20 | -3.91 | 63.01** | 56.71** | -3.69 |
| 7. | SHUATS URD 79- VALLABH URD x T-4 | 43.59** | 43.59** | 24.44** | 31.75* | 23.53 | 23.09 | 116.61** | 106.24** | 16.96** |
| 8. | SHUATS URD 80- VALLABH URD x L-6 | 8.43 | 2.27 | 0.06 | 45.09* | 26.48 | 10.30 | -9.26 | -12.28 | -50.26** |
| 9. | SHUATS URD 81- VALLABH URD x MASH-338 | 42.11** | 38.46** | 20.00** | 40.76* | 17.11 | 2.13 | 13.18 | 3.24 | -28.99** |
| 10. | SHUATS URD 82- VALLABH URD x KU-96-7 | 19.48** | 17.95* | 2.22 | 3.04 | -0.75 | -6.57 | -27.95* | -33.31** | -55.58** |
| 11. | SHUATS URD 83- VALLABH URD x MU-44 | 30.86** | 26.19** | 17.78* | 30.62 | 11.20 | -3.02 | 33.49** | 33.17* | -24.48** |
| 12. | SHUATS URD 84- VALLABH URD x NDUK-13-6 | 13.58* | 9.52 | 2.22 | 24.69 | 18.82 | 14.39 | 39.96** | 39.13** | -21.10** |
| 13. | SHUATS URD 85- VALLABH URD x PU-31 | 44.62** | 20.51* | 4.44 | 29.58 | 19.55 | 4.26 | 29.80* | 15.05 | -34.76** |
| 14. | SHUATS URD 86- LBG -20 x LBG-791 | 23.81** | 23.81** | 15.56* | 21.47 | 14.56 | 14.56 | 78.56** | 75.51** | 15.00 |
| 15. | SHUATS URD 87- LBG-20 x VALLABH URD | 44.44** | 39.29** | 30.00** | 15.75 | 8.35 | 8.35 | -37.08** | -41.31** | -61.55** |
| 16. | SHUATS URD 88- LBG-20 x KU-96-7 | 7.50 | 2.38 | -4.44 | 1.74 | -1.24 | -1.24 | 6.28 | 5.42 | -29.78** |
| 17. | SHUATS URD 89- LBG-791 x VALLABH URD | 18.52** | 14.29 | 6.67 | 11.52 | 10.62 | -1.95 | 20.41 | 14.15 | -27.76** |
| 18. | SHUATS URD 90- LBG-791 x NDUK-13-6 | 7.14 | 7.14 | 0.07 | 12.20 | 7.75 | 3.73 | 0.33 | -5.42 | -40.14** |
| 19. | SHUATS URD 91- LBG-791 x T-4 | 51.85** | 46.43** | 36.67** | 79.25** | 69.34** | 68.74** | 123.16** | 101.99** | 27.84** |
| 20. | SHUATS URD 92- LBG-791 x NDUK-13-4 | 8.24 | 6.98 | 2.22 | 93.51** | 73.15** | 53.46** | -3.10 | -10.11 | -43.11** |
| 21. | SHUATS URD 93- LBG-791 x PU-31 | 44.12** | 16.67** | 8.89 | 17.72 | 7.82 | -4.44 | 20.48 | 1.95 | -35.48** |

** and * Significant at 1% and 5% level of significance respectively

**TABLE 1.2 (c)** Heterosis, heterobeltiosis and standard heterosis for 13 characters of 21 Blackgram genotypes

| S.No | Genotypes | No. of Seeds/pod | | | Pod length | | | Days to maturity | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ha | Hb | Hc | Ha | Hb | Hc | Ha | Hb | Hc |
| 1. | SHUATS URD 73- PU-11-14 X KU-96-7 | -5.00 | -9.52 | -9.52 | 5.35 | 3.17 | -0.76 | -8.46** | -8.91** | -18.22** |
| 2. | SHUATS URD 74- PU-11-14 X KPU-63-189 | -12.82 | -15.00 | -19.05* | 1.61 | 0.08 | -3.82 | 7.39** | 5.83* | -3.11 |
| 3. | SHUATS URD 75- PU-11-14 X NDUK-13-6 | 5.56 | 10.43 | 19.05* | -3.36 | -8.73 | -12.21* | -2.40 | -6.02** | -9.78** |
| 4. | SHUATS URD 76- PU-11-14 x LBG-11 | 22.22** | 15.79 | 4.76 | -1.96 | -3.10 | -4.58 | -6.57** | -9.00** | -14.67** |
| 5. | SHUATS URD 77- VALLABH URD x LBG-7 | 11.11 | 5.26 | -4.76 | 12.56* | 9.82 | 8.40 | -11.53** | -12.96** | -16.44** |
| 6. | SHUATS URD 78- VALLABH URD x PU-38 | -5.56 | -10.53 | -19.05* | -2.60 | -2.76 | -8.40 | -4.37* | -5.74* | -12.44** |
| 7. | SHUATS URD 79- VALLABH URD x T-4 | -2.86 | -5.56 | -19.05* | -4.20 | -7.32 | -12.98* | -3.23 | -6.67** | -6.67** |
| 8. | SHUATS URD 80- VALLABH URD x L-6 | 5.56 | 0.04 | -9.52 | -1.57 | -4.58 | -4.58 | 1.93 | 0.96 | -6.22** |
| 9. | SHUATS URD 81- VALLABH URD x MASH-338 | -8.57 | -11.11 | -23.81** | 10.73 | 15.45* | 20.61** | -3.61 | -4.31 | -11.11** |
| 10. | SHUATS URD 82- VALLABH URD x KU-96-7 | 15.79* | 4.76 | 4.76 | 12.39* | 11.38 | 4.58 | 4.62* | 2.87 | -4.44* |
| 11. | SHUATS URD 83- VALLABH URD x MU-44 | 16.67* | 10.53 | 0.09 | 8.15 | 5.69 | -0.76 | 8.25** | 6.70** | -0.89 |
| 12. | SHUATS URD 84- VALLABH URD x NDUK-13-6 | 11.76 | 11.76 | -9.52 | 0.43 | -4.07 | -9.92 | -8.71** | -10.19** | -13.78** |
| 13. | SHUATS URD 85- VALLABH URD x PU-31 | 23.53** | 23.53* | 0.05 | -1.56 | -2.44 | -8.40 | -12.50** | -15.25** | -16.00** |
| 14. | SHUATS URD 86- LBG -20 x LBG-791 | -2.56 | -5.00 | -9.52 | -3.81 | -7.19 | -8.40 | -2.35 | -3.70 | -7.56** |
| 15. | SHUATS URD 87- LBG-20 x VALLABH URD | -2.70 | -10.00 | -14.29 | 8.72 | 9.76 | 15.27** | -7.88** | -8.10** | -14.22** |
| 16. | SHUATS URD 88- LBG-20 x KU-96-7 | -2.44 | -4.76 | -4.76 | 16.18** | 15.89* | 6.87 | 0.49 | -1.43 | -8.00** |
| 17. | SHUATS URD 89- LBG-791 x VALLABH URD | 16.67 | 10.53 | 0.10 | -4.72 | -7.04 | -8.24 | -4.47* | -6.02** | -9.78** |
| 18. | SHUATS URD 90- LBG-791 x NDUK-13-6 | 5.56 | 10.53 | 19.05* | -0.54 | -7.19 | -8.40 | -10.65** | -10.65** | -14.22** |
| 19. | SHUATS URD 91- LBG-791 x T-4 | 8.11 | 5.26 | -4.76 | 14.61** | 8.28 | 6.87 | -6.58** | -8.44** | -8.44** |
| 20. | SHUATS URD 92- LBG-791 x NDUK-13-4 | 0.07 | -5.26 | -14.29 | -0.12 | -4.87 | -6.11 | 0.09 | -2.78 | -6.67** |
| 21. | SHUATS URD 93- LBG-791 x PU-31 | -5.56 | -10.53 | -19.05* | -0.04 | -3.33 | -4.58 | -12.53** | -13.90** | -14.67** |

** and * Significant at 1% and 5% level of significance respectively

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**TABLE 1.2 (d)** Heterosis, heterobeltiosis and standard heterosis for 13 characters of 21 Blackgram genotypes

| S.No | Genotypes | 100 seed weight | | | Biological Yield | | | Harvest index | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ha | Hb | Hc | Ha | Hb | Hc | Ha | Hb | Hc |
| 1. | SHUATS URD 73- PU-11-14 X KU-96-7 | 9.04 | 6.82 | -25.46** | 29.71** | 2.08 | -4.73 | -24.57** | -41.52** | -41.67** |
| 2. | SHUATS URD 74- PU-11-14 X KPU-63-189 | -6.07 | -8.73 | -36.31** | 51.50** | 19.53* | 11.55 | 43.87** | 56.52** | 56.52** |
| 3. | SHUATS URD 75- PU-11-14 X NDUK-13-6 | -8.91 | -12.88 | -39.21** | 14.86* | 4.81 | -2.18 | -19.75 | -20.89 | -55.29** |
| 4. | SHUATS URD 76- PU-11-14 x LBG-11 | -11.16 | -11.67 | -37.65** | 18.39* | -9.88 | -15.89* | -6.56 | -19.02 | -39.37** |
| 5. | SHUATS URD 77- VALLABH URD x LBG-7 | -13.58* | -30.22** | -30.22** | 99.61** | 98.69** | 1.40 | -11.91 | -12.02 | -22.23** |
| 6. | SHUATS URD 78- VALLABH URD x PU-38 | 9.04 | 3.75 | -29.35** | 71.39** | 61.92** | -17.37* | 7.26 | 6.88 | -5.53 |
| 7. | SHUATS URD 79- VALLABH URD x T-4 | -2.08 | -3.99 | -38.57** | 39.00** | 19.65* | -15.38* | -0.57 | -10.45 | -20.85** |
| 8. | SHUATS URD 80- VALLABH URD x L-6 | -11.16 | -12.74 | -44.37** | 60.33** | 54.89** | -15.19* | 0.66 | -0.31 | -10.14 |
| 9. | SHUATS URD 81- VALLABH URD x MASH-338 | 5.84 | 4.25 | -35.90** | 84.90** | 63.60** | 8.48 | -25.02** | -25.39** | -34.05** |
| 10. | SHUATS URD 82- VALLABH URD x KU-96-7 | -0.09 | -4.16 | -35.85** | 176.46** | 169.90** | 44.60** | 51.10** | 53.88** | 54.00** |
| 11. | SHUATS URD 83- VALLABH URD x MU-44 | 10.43 | 6.78 | -29.70** | 185.44** | 178.34** | 42.05** | -37.27** | -39.15** | -42.78** |
| 12. | SHUATS URD 84- VALLABH URD x NDUK-13-6 | 7.51 | 5.65 | -32.71** | 158.81** | 115.17** | 65.68** | -46.65** | -56.27** | -61.35** |
| 13. | SHUATS URD 85- VALLABH URD x PU-31 | 23.67** | 22.74** | -24.54** | 143.06** | 132.81** | 29.76** | -38.62** | -41.28** | -48.09** |
| 14. | SHUATS URD 86- LBG -20 x LBG-791 | -18.50** | -35.09** | -35.09** | 110.26** | 105.51** | 8.83 | 25.81** | 24.52** | 9.78 |
| 15. | SHUATS URD 87- LBG-20 x VALLABH URD | 5.09 | 3.21 | -36.54** | 185.23** | 180.05** | 48.31** | 51.86** | 52.42** | 57.94** |
| 16. | SHUATS URD 88- LBG-20 x KU-96-7 | 9.01 | 2.77 | -31.21** | 175.04** | 173.45** | 46.50** | -29.22** | -33.97** | -34.14** |
| 17. | SHUATS URD 89- LBG-791 x VALLABH URD | 22.70** | 37.59** | 37.59** | 167.51** | 166.28** | 35.89** | 52.76** | 52.83** | 58.30** |
| 18. | SHUATS URD 90- LBG-791 x NDUK-13-6 | 23.88** | 37.70** | 37.70** | 32.32** | 9.61 | -15.60* | -30.12** | -42.66** | -49.45** |
| 19. | SHUATS URD 91- LBG-791 x T-4 | -19.28** | -33.82** | -33.82** | 55.34** | 33.20** | -5.80 | -25.06** | -32.43** | -40.43** |
| 20. | SHUATS URD 92- LBG-791 x NDUK-13-4 | -15.93** | -30.22** | -30.22** | -14.28 | -35.46** | -35.46** | 0.18 | -13.27 | -23.53** |
| 21. | SHUATS URD 93- LBG-791 x PU-31 | -4.05 | -22.97** | -22.97** | 11.83 | 6.64 | -40.56** | 3.93 | -0.45 | -12.23 |

** and * Significant at 1% and 5% level of significance respectively

**TABLE 1**.2 (e) Heterosis, heterobeltiosis and standard heterosis for 13 characters of 21 Blackgram genotypes

| S. No | Genotypes | Seed yield per plant | | |
|---|---|---|---|---|
| | | Ha | Hb | Hc |
| 1. | SHUATS URD 73- PU-11-14 X KU-96-7 | 6.81 | 4.30 | -13.60* |
| 2. | SHUATS URD 74- PU-11-14 X KPU-63-189 | -9.11 | -13.38 | -24.53** |
| 3. | SHUATS URD 75- PU-11-14 X NDUK-13-6 | -7.93 | -14.54 | -32.53** |
| 4. | SHUATS URD 76- PU-11-14 x LBG-11 | 15.67* | -0.70 | -21.61** |
| 5. | SHUATS URD 77- VALLABH URD x LBG-7 | 75.68** | 74.98** | 21.70** |
| 6. | SHUATS URD 78- VALLABH URD x PU-38 | 95.60** | 74.52** | 21.38** |
| 7. | SHUATS URD 79- VALLABH URD x T-4 | 50.50** | 49.30** | 3.84 |
| 8. | SHUATS URD 80- VALLABH URD x L-6 | 31.94** | 25.74** | -3.47 |
| 9. | SHUATS URD 81- VALLABH URD x MASH-338 | 39.18** | 23.23** | 11.20 |
| 10. | SHUATS URD 82- VALLABH URD x KU-96-7 | 35.80** | 24.92** | 3.47 |
| 11. | SHUATS URD 83- VALLABH URD x MU-44 | 78.76** | 77.24** | 25.40** |
| 12. | SHUATS URD 84- VALLABH URD x NDUK-13-6 | 46.90** | 44.84** | 0.74 |
| 13. | SHUATS URD 85- VALLABH URD x PU-31 | 72.62** | 72.40** | 20.22** |
| 14. | SHUATS URD 86- LBG -20 x LBG-791 | 164.64** | 160.60** | 85.47** |
| 15. | SHUATS URD 87- LBG-20 x VALLABH URD | 37.59** | 36.02** | -3.19 |
| 16. | SHUATS URD 88- LBG-20 x KU-96-7 | 94.47** | 80.78** | 49.75** |
| 17. | SHUATS URD 89- LBG-791 x VALLABH URD | 27.05** | 26.55** | -11.99 |
| 18. | SHUATS URD 90- LBG-791 x NDUK-13-6 | -4.20 | -5.16 | -34.57** |
| 19. | SHUATS URD 91- LBG-791 x T-4 | 25.05** | 24.55** | -14.07* |
| 20. | SHUATS URD 92- LBG-791 x NDUK-13-4 | -9.20 | -23.28** | -23.28** |
| 21. | SHUATS URD 93- LBG-791 x PU-31 | 17.01 | 16.39 | -18.83** |

** and * Significant at 1% and 5% level of significance respectively

**Standard heterosis:** The standard heterosis of the crosses revealed that the cross LBG-20 X KU-96-7 displayed high significant negative standard heterosis for days to 50% flowering whereas VALLABH URD X MU-44, VALLABH URD X NDUK-13-6 and LBG-20 X LBG-791 for days to 50% pod setting, PU-11-14 X KPU-63-189 and LBG-791 X NDUK-13-4 for plant height and VALLABH URD X L-6 for days to maturity followed by high significant positive standard heterosis for LBG-791 X T-4 for primary branches per plant, LBG-791 X T-4 for clusters per plant, LBG-20 X VALLABH URD for pods per plant, VALLABH URD X MASH 338 for seeds per pod, VALLABH URD X MASH 338 for pod length, VALLABH URD X L-6 for 100 seed weight, VALLABH URD X NDUK-13-6 for biological yield, PU-11-14 X KPU-63-189 URD for harvest index and MASH 338 X PU-38 for seed yield per plant.

## CONCLUSION

Analysis of variance and per se performance concluded that the presence of sufficient amount of variability among 38 genotypes. In case of GCV and PCV, PCV values were high when comparing to the GCV values it indicates that there was a less role of environment for all the 13 characters studied in this experiment. High heritability coupled with high genetic advance were observed in biological yield, seed yield per plant, days to 50% flowering and number of pods per plant revealed that there was the presence of additive gene effects and selection for improvement of such characters would be rewarding. The cross combinations, LBG-20 X LBG-791, VALLABH URD X PU-38 and LBG-20 X KU-96-7 also showed the high positive significant values in Heterosis, Heterobeltiosis and Standard Heterosis for the character seed yield per plant.

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