

Influence of cropping systems on combining ability and gene action for grain yield and its components in blackgram (*Vigna mungo*)

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ABSTRACT

Field experiments were conducted at Regional Research Station, Himachal Pradesh Agricultural University, Palampur during rainy (*kharif*) season of 2003–04 and 2004–05 to study the effect of cropping system on the nature and magnitude of gene action for seed yield and its component traits in the parents and progenies of line×tester cross in blackgram [*Vigna mungo* (L.) Hepper], grown both as a sole crop and intercrop with maize (*Zea mays* L.). There was not much effect of cropping system in the manifestation of phenotypic and genotypic variability. There were strong progenies×cropping system interactions for different traits. Cropping system had a large influence on the phenotypic expression of yield and its components. Both additive (σ^2A) and non-additive (σ^2D) genetic variances were important in the genetic determination of seed yield and its components. However, the ratio of σ^2A to σ^2D was greater under monoculture than under intercropping for almost all the traits except harvest index, seeds/pod, pods/plant and days to 50% flowering, where it increased indicating that cropping systems influence the genetic control of important yield component traits. However, the occurrence of low genotypic correlations for seed yield and its components across and cropping systems justify the selection of different parents and crosses for monoculture and in association with blackgram.

Key words: Blackgram, Cropping system, Combining ability, Gene action, Intercropping

Research on increasing plant productivity in developing countries encourages the maintenance of traditional farming systems. One such instance is the intercropping of blackgram (*Vigna mungo* (L.) Hepper) with maize (*Zea mays* L.) as secondary crop in the hilly tracts of north-western India. This practice aims to minimize the probability of total crop failures under abnormal weather conditions and to increase total productivity/unit land area; besides optimizing the land use and farming inputs.

The Indian blackgram breeding programme has concentrated mainly on the development of high-yielding varieties adapted to sole cropping. The varieties developed to date are also being intercropped with maize under the assumption that correlated improvement will occur in the intercrop. However significant genotypes × cropping system interactions for various growth traits have been reported in blackgram–maize cropping systems (Mohar *et al.* 2009). It is, therefore, imperative to identify the specific genetic traits

of blackgram which limit productivity when intercropped with maize. These traits and their genetic control need to be determined to formulate suitable breeding and selection criteria for developing ideotypes of blackgram specifically adapted to sole and intercrop system of production.

MATERIALS AND METHODS

Twelve genetically diverse lines of blackgram ‘HPU1’ (1), ‘VB 17’ (2), ‘HPBU 124’ (3), ‘HPBU 125’ (4), ‘HPBU 126’ (5), ‘HPBU 128’ (6), ‘HPBU 129’ (7), ‘HPBU 130’ (8), ‘HPBU 131’ (9), ‘HPBU 133’ (10), ‘UL 338’ (11) and ‘MX 17’ (12) were crossed with 4 diverse pollen parents ‘T9’ (1), ‘PDU 1’ (2), ‘UG 218’ (3) and ‘Palampur 93’ (4) in a line×tester mating design (Kempthorne 1957). The 48 F₂'s were grown along with parents and evaluated for their performance at the Regional Research Station, Himachal Pradesh Agricultural University, Bajaura (31°48'N, 77°00'E, 1099 m amsl) during rainy season (*kharif*) 2003–04 and 2004–05, where sole and intercropping experiments were planted simultaneously. The experiment was laid out in split-plot design replicated twice where the main plots were cropping systems, viz sole crop and intercrop with maize (fixed effects), while sub-plots comprised 16 parents and their 48 F₂ crosses (random effects). In the sole

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crop, sub-plots comprised 2 rows of blackgram each 2 m long and 30 cm apart. Under intercropping, sub-plot treatments were identical except that a row of maize (early composite, a locally recommended variety in the region) was added between successive 2 rows of blackgram and maize were spaced at 8 and 20 cm within-rows, respectively. The fertilizer schedule of 20 kg N, 27 kg P and 33 kg K/ha was applied at sowing. Maize was planted @ 20 kg/ha in intercropping to meet the desired plant population. Besides the full dose of fertilizers for maize, 20 kg N and 11 kg P/ha were also applied as an allowance to urdbean in intercrop. Two hoeing and weedings were undertaken in the early stages to remove weeds. The experiments were conducted under rainfed conditions.

Observations were recorded on 5 and 20 randomly selected plants/replication for parents and F₂'s respectively, on seed yield/plant (g), harvest index (%), 100-seed weight (g), seeds/pod, pods/plant, biological yield/plant (g), plant height (cm), pod-bearing branches/plant, days to 50% flowering and maturity. Analysis of variance was undertaken under the full split-plot design (mixed model) as suggested (Panse and Sukhatme 1967). Analysis of variance for all the traits and covariances among each pair of traits were also conducted for each cropping system separately. Genotypic variances for each trait and genotypic co-variances among traits were determined by equating mean squares and products of their expectations. Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h²) and expected genetic advance (GA) were estimated by usual methods. Subsequently combining ability and gene action were estimated under each cropping system (Kempthorne 1957).

Correlations for all traits in 2 cropping systems were calculated by using the formula

$$r_g = \frac{\sigma_{GMI}}{(\sigma^2_{GM})(\sigma^2_{GI})}$$

where r_g is the genotypic correlation and σ^2_{GM} and σ^2_{GI} are the estimates of genotypic variances in monoculture and intercrop, respectively and σ_{GMI} is the genotypic covariance between genotype means in 2 cropping systems and corresponds to the genotypic variance because the genotypes were independently randomized for each system and the errors are therefore, independent.

RESULTS AND DISCUSSION

Substantial differences in mean performance of the parents were found for all traits investigated under both cropping systems and the comparison in average means revealing higher in sole cropping than under associated cropping system except days to 50% flowering and maturity, where these increased under intercropping (Table 1). The range values were higher for seed yield/plant, harvest index, pods/plant, biological yield/plant, plant height and pod

Table 1 Mean of parents entering the line × tester cross averaged over blocks for seed yield and its component traits expressed in sole cropping (S) and intercropping (I)

| Character parent | Seed yield/plant (g) | | Harvest index (%) | | 100-seed weight (g) | | Seeds/pod | | Pods/plant | | Biological yield/plant (g) | | Plant height (cm) | | Pod-bearing branches/plant | | Days to 50% flowering | | Days to maturity | |
|------------------|----------------------|------|-------------------|-------|---------------------|------|-----------|------|------------|-------|----------------------------|-------|-------------------|-------|----------------------------|------|-----------------------|-------|------------------|-------|
| | S | I | S | I | S | I | S | I | S | I | S | I | S | I | S | I | S | I | S | I |
| 'HPU 1' | 13.88 | 6.36 | 41.36 | 37.31 | 6.12 | 4.15 | 5.10 | 4.17 | 47.55 | 32.50 | 33.54 | 17.36 | 60.50 | 38.60 | 11.00 | 6.85 | 42.20 | 45.50 | 91.20 | 96.40 |
| 'VB 17' | 14.50 | 4.85 | 28.94 | 30.14 | 4.89 | 5.53 | 6.10 | 5.07 | 47.00 | 20.25 | 51.92 | 16.05 | 57.55 | 36.40 | 9.07 | 6.30 | 41.20 | 45.00 | 93.20 | 97.30 |
| 'HPBU 124' | 5.78 | 3.68 | 26.27 | 21.99 | 5.02 | 4.93 | 5.30 | 4.52 | 21.80 | 16.85 | 28.54 | 13.58 | 51.88 | 37.70 | 7.90 | 6.80 | 42.20 | 46.50 | 92.10 | 97.00 |
| 'HPBU 125' | 7.12 | 5.32 | 31.09 | 33.40 | 4.43 | 5.31 | 5.60 | 5.25 | 27.15 | 19.12 | 28.84 | 13.87 | 54.12 | 40.65 | 8.38 | 6.60 | 42.50 | 46.50 | 91.10 | 96.20 |
| 'HPBU 126' | 7.06 | 4.38 | 37.28 | 41.04 | 4.45 | 5.03 | 6.07 | 4.81 | 25.50 | 16.60 | 23.03 | 11.05 | 49.50 | 31.40 | 7.80 | 5.80 | 41.20 | 45.50 | 93.20 | 97.50 |
| 'HPBU 128' | 8.78 | 4.57 | 32.47 | 29.97 | 4.57 | 4.65 | 5.45 | 4.88 | 28.38 | 20.55 | 43.32 | 11.94 | 51.31 | 30.95 | 8.30 | 6.60 | 42.50 | 47.00 | 93.30 | 97.20 |
| 'HPBU 129' | 8.18 | 4.28 | 19.06 | 27.58 | 5.51 | 5.27 | 5.47 | 5.05 | 27.70 | 20.83 | 49.32 | 15.65 | 56.96 | 38.32 | 8.50 | 6.62 | 44.20 | 47.50 | 95.50 | 98.50 |
| 'HPBU 130' | 4.93 | 3.38 | 40.50 | 40.95 | 4.22 | 4.15 | 4.45 | 5.78 | 26.00 | 17.33 | 12.20 | 7.27 | 37.70 | 27.55 | 8.10 | 6.57 | 41.20 | 45.00 | 92.20 | 97.20 |
| 'HPBU 131' | 6.03 | 5.66 | 32.09 | 32.01 | 4.91 | 4.87 | 5.11 | 5.22 | 23.80 | 21.25 | 22.61 | 13.31 | 49.20 | 34.53 | 8.20 | 6.43 | 41.50 | 45.50 | 91.00 | 95.50 |
| 'HPBU 133' | 4.27 | 4.08 | 41.99 | 38.43 | 5.02 | 4.01 | 5.30 | 5.23 | 20.83 | 19.40 | 16.97 | 10.59 | 44.90 | 38.70 | 6.40 | 6.75 | 43.40 | 47.00 | 92.00 | 96.50 |
| 'UL 338' | 5.12 | 4.82 | 41.49 | 35.57 | 4.33 | 3.88 | 4.94 | 4.69 | 25.62 | 21.45 | 14.61 | 10.80 | 45.31 | 27.70 | 7.20 | 6.90 | 41.40 | 45.50 | 92.50 | 96.00 |
| 'MX 17' | 8.53 | 5.47 | 43.00 | 34.50 | 4.72 | 5.75 | 4.72 | 4.44 | 38.20 | 21.75 | 23.44 | 15.55 | 45.49 | 31.00 | 9.00 | 7.55 | 40.50 | 45.00 | 92.20 | 95.50 |
| 'T 9' | 7.51 | 3.51 | 41.69 | 37.08 | 4.28 | 4.04 | 4.92 | 4.81 | 33.65 | 19.25 | 18.70 | 9.30 | 48.50 | 38.95 | 10.05 | 6.15 | 40.50 | 45.50 | 84.50 | 90.20 |
| 'PDU 1' | 7.03 | 4.94 | 33.49 | 37.47 | 4.95 | 4.65 | 4.76 | 3.84 | 26.30 | 26.33 | 21.26 | 11.82 | 62.60 | 35.50 | 9.05 | 7.45 | 41.60 | 46.50 | 88.20 | 94.00 |
| 'UG 218' | 11.21 | 6.88 | 56.65 | 41.21 | 5.62 | 4.65 | 5.30 | 4.93 | 41.28 | 32.30 | 27.40 | 17.00 | 43.33 | 33.50 | 9.65 | 7.90 | 41.50 | 46.00 | 91.30 | 96.50 |
| 'Palampur 93' | 8.34 | 3.33 | 44.70 | 41.10 | 5.33 | 4.66 | 5.32 | 4.06 | 29.20 | 17.83 | 24.15 | 8.75 | 55.80 | 46.53 | 7.15 | 6.84 | 41.60 | 45.50 | 93.00 | 98.55 |
| Mean | 8.01 | 4.72 | 37.00 | 34.88 | 4.89 | 4.72 | 5.24 | 4.79 | 30.62 | 21.47 | 237.49 | 12.74 | 50.91 | 36.74 | 8.48 | 6.75 | 41.82 | 45.93 | 91.65 | 96.25 |
| SEM± | 1.07 | 0.66 | 3.07 | 1.94 | 0.33 | 0.24 | 0.29 | 0.22 | 2.98 | 2.49 | 3.39 | 1.66 | 2.81 | 2.00 | 0.71 | 0.57 | 0.72 | 0.67 | 1.47 | 1.22 |
| CD (P=0.05) | 2.27 | 1.40 | 6.53 | 4.13 | 0.70 | 0.51 | 0.61 | 0.46 | 6.3474 | 5.30 | 7.22 | 3.53 | 5.98 | 4.26 | 1.51 | 1.21 | 1.53 | 1.42 | 3.13 | 2.59 |

Table 2 Range, mean, phenotypic (PCV) and genotypic (GCV) coefficient of variation, heritability (H) and genetic advance (GA) for different traits in urdbean under 2 cropping systems

| Character | Range | | Mean | | PCV (%) | | GCV (%) | | H | | GA | |
|--------------------------------|--------------|--------------|-------|-------|---------|-------|---------|-------|-------|-------|-------|-------|
| | S | I | S | I | S | I | S | I | S | I | S | I |
| Seed yield / plant (g) | 14.50– 4.27 | 6.88– 3.33 | 8.01 | 4.72 | 28.42 | 28.46 | 21.03 | 23.47 | 0.548 | 0.661 | 2.55 | 2.21 |
| Harvest index (%) | 56.65– 19.06 | 41.21– 21.99 | 38.32 | 37.29 | 18.13 | 13.11 | 14.13 | 10.81 | 0.607 | 0.680 | 8.69 | 6.85 |
| 100-seed weight (g) | 6.12– 4.22 | 5.75– 3.88 | 4.94 | 4.05 | 10.47 | 12.00 | 4.90 | 5.23 | 0.219 | 0.592 | 0.23 | 0.66 |
| Seeds/pod | 6.10– 4.45 | 5.78– 3.84 | 5.23 | 4.85 | 8.93 | 9.06 | 4.22 | 6.22 | 0.223 | 0.472 | 0.21 | 0.41 |
| Pods/plant | 47.55– 20.83 | 32.50– 16.60 | 31.11 | 27.46 | 23.96 | 24.69 | 19.82 | 21.10 | 0.684 | 0.730 | 10.51 | 10.20 |
| Biological yield/ plant (g) | 51.92– 12.20 | 17.36– 7.27 | 23.15 | 14.26 | 36.94 | 29.90 | 30.57 | 24.94 | 0.685 | 0.696 | 12.06 | 10.11 |
| Plant height (cm) | 60.50– 37.70 | 40.65– 27.55 | 48.73 | 40.63 | 14.62 | 18.00 | 12.17 | 16.59 | 0.693 | 0.850 | 11.17 | 12.80 |
| Pod-bearing branches/ plant | 11.00– 6.40 | 7.55– 6.30 | 8.88 | 7.35 | 14.15 | 13.71 | 8.26 | 8.08 | 0.341 | 0.347 | 0.88 | 0.72 |
| Days to 50% flowering | 43.40– 40.50 | 47.50– 45.00 | 41.16 | 45.41 | 2.71 | 2.45 | 1.09 | 1.23 | 0.162 | 0.254 | 0.37 | 0.58 |
| Days to maturity | 95.50– 91.00 | 98.50– 95.50 | 89.86 | 94.64 | 3.86 | 3.02 | 3.01 | 2.08 | 0.610 | 0.472 | 4.35 | 3.78 |

S, Sole cropping; I, intercropping

bearing branches/plant under sole cropping than under intercropping (Table 2). The range values were higher for days to 50% flowering and maturity in intercropping than under sole cropping. There was no much difference in the range values for 100-seed weight and seeds/pod under both cropping systems. However, Johnston *et al.* (1969) showed that shading, as occurred in the intercrop system, reduced photosynthetic activity. Other factors which would be expected to vary between cropping systems are canopy structure, radiation intensity, temperature, wind and CO₂ concentration, these were all found to influence photosynthetic processes (Okibago 1975) and consequently seed yield. PCV and GCV values were almost comparable under both cropping systems. There was not much effect of cropping system on the manifestation of genotypic and phenotypic variability. Comparison of the estimates of heritability and genetic advance revealed for all traits were almost similar in both cropping systems. The term heritability and genetic advance are normally applied to situation where the reference population is clearly defined (Zimmermann *et al.* 1984). In this study, our reference population includes promising lines and F₂ families. A breeder would not normally be concerned with selecting among such F₂ families. Our intent in using the heritability and genetic advance concept herein has been to characterize the relative ease with which these traits may be selected in 2 cropping systems, rather than to provide strict measures of heritability in urdbean. In an applied breeding programme, the reference population would normally be single plant or progenies within crosses which may show less genetic variability (Zimmermann *et al.* 1984). There were significant differences in the performance of parents and crosses for seed yield/plant, biological yield/plant, pod-bearing branches/plant and plant height. However, harvest index, 100-seed weight, seeds/pod and pods/plant was comparable under both cropping systems. Days to 50%

flowering and maturity also revealed significant differences (Table 3).

The differential response of the parents and their crosses was confirmed from the analysis of variance under 2 cropping systems. Cropping system effects were significant for pods/plant, days to 50% flowering and maturity. However, the progenies (parents and crosses) were significant for all the traits in different cropping systems. Likewise, the progenies × cropping systems interaction were also significant for majority of traits except harvest index, pod-bearing branches/plant, days to 50% flowering and maturity (Table 4). Subsequent proof of the differential response of the parents and their crosses under both the cropping systems was manifested in the analysis of variance that cropping system effects were significant for pods/plant, days to 50% flowering and maturity, however non-significant cropping system effects for other traits cannot be accepted with complete impunity since the main plot treatments (cropping system) are being compared with error (a) both having 1 degree of freedom. Nevertheless, precise information on the differential behavior of progenies (sub-plots) in respect of these traits under different cropping systems was provided by progenies × cropping systems interaction. The precision of such estimates was much greater since the interaction, variances were compared with Error (b) having 126 degrees of freedom. The progenies had a strong significant interaction with the cropping systems in which these were grown with respect to seed yield and its major component traits. Separate breeding strategy for intercropped urdbean was indicated for seed yield and its component traits for both parents and crosses. The results are similar to those obtained for soybean (*Glycine Max.* L. Merr.)–maize (Sood and Sood 2006) intercropping systems for seed yield and different yield components and justify separate breeding programmes for each cropping system. Nevertheless, there was no

Table 3 Mean comparative performance of parents and crosses in 2 cropping systems

| Trait | Cropping system | Parent | | | Crosses | | |
|----------------------------|-----------------|------------------|--------|----------------|------------------|--------|----------------|
| | | Mean performance | SE (m) | Difference S-I | Mean performance | SE (m) | Difference S-I |
| Seed yield/plant (g) | S | 7.94 | 1.57 | 2.02** | 8.02 | 2.95 | 3.30* |
| | I | 5.92 | 1.48 | | 4.72 | 1.04 | |
| Harvest index | S | 38.76 | 5.11 | 0.69 | 37.01 | 8.84 | 2.03 |
| | I | 38.07 | 3.83 | | 34.98 | 5.54 | |
| 100-seed weight (g) | S | 4.98 | 0.34 | 0.53 | 4.90 | 0.53 | 0.21 |
| | I | 4.45 | 0.44 | | 4.69 | 0.58 | |
| Seeds/pod | S | 5.22 | 0.35 | 0.35 | 5.23 | 0.44 | 0.43 |
| | I | 4.87 | 0.32 | | 4.80 | 0.50 | |
| Pods/plant | S | 31.39 | 6.33 | 2.06 | 30.62 | 8.46 | 9.15 |
| | I | 29.33 | 5.44 | | 21.47 | 4.86 | |
| Biological yield/plant (g) | S | 21.70 | 5.48 | 6.94** | 27.49 | 11.72 | 14.75* |
| | I | 14.76 | 4.07 | | 12.74 | 3.04 | |
| Plant height (cm) | S | 48.00 | 6.39 | 6.08* | 50.91 | 6.75 | 14.16* |
| | I | 41.92 | 6.71 | | 36.75 | 6.70 | |
| Pod-bearing branches/plant | S | 9.01 | 0.95 | 1.46* | 8.48 | 1.15 | 1.72* |
| | I | 7.55 | 0.81 | | 6.76 | 0.52 | |
| Days to 50% flowering | S | 41.03 | 0.78 | -4.21** | 41.56 | 1.02 | -4.38** |
| | I | 45.24 | 0.84 | | 45.94 | 0.79 | |
| Days to maturity | S | 89.34 | 3.20 | -4.77** | 91.41 | 2.47 | -4.81 |
| | I | 94.11 | 2.57 | | 96.22 | 1.98 | |

S, Sole cropping; I, intercropping; * $P=0.05$; ** $P=0.01$

Table 4 Analysis of variance for seed yield and its components in different cropping systems

| Source of variation | df | Seed yield/plant | Harvest index | 100-seed weight | Seeds/pod | Pods/plant | Biological yield/plant | Plant height | Pod-bearing branches/plant | Days to 50% flowering | Days to maturity |
|------------------------------|-----|------------------|---------------|-----------------|-----------|------------|------------------------|--------------|----------------------------|-----------------------|------------------|
| Replication | 1 | 18.26 | 5.75 | 0.24 | 0.50 | 1.59 | 128.14 | 246.53 | 2.94 | 10.56 | 5.00 |
| Cropping systems | 1 | 349.81 | 67.06 | 12.80 | 8.77 | 940.17* | 5061.02 | 4199.19 | 148.76 | 1156.00* | 1463.00* |
| Error(a) | 1 | 14.94 | 0.50 | 0.28 | 0.18 | 0.78 | 78.70 | 181.37 | 6.10 | 0.41 | 0.10 |
| Progenies | 63 | 8.26* | 98.86* | 0.43* | 0.41* | 146.30* | 94.81* | 142.65* | 2.44* | 2.73* | 32.42* |
| Progenies × cropping systems | 63 | 3.97* | 18.79 | 0.37* | 0.15 | 26.79* | 59.12* | 42.25* | 1.05 | 0.34 | 0.85 |
| Error (b) | 126 | 1.61 | 13.25 | 0.18 | 0.14 | 15.13 | 14.27 | 11.93 | 0.85 | 0.98 | 3.68 |

* $P=0.05$

progeny×cropping systems interaction for harvest index, seeds/pod, pod-bearing branches, days to flowering and maturity. In view of it, for accomplishing breeding for these traits one can select in either cropping system for performance in the other. The results were similar to those obtained for common bean–maize and soybean–maize cropping systems (Sharma *et al.* 1993).

The magnitude of the mean squares of the combining ability of lines, testers and lines×testers differed significantly

for some characters under both the cropping systems (Table 5). It was more pronounced for lines and testers than that of lines×testers. The combining ability of lines, testers and lines×testers in one cropping system cannot be relied upon for the other cropping system. On comparing the relative magnitude of σ^2A (additive variance) and σ^2D (dominance variance) for different traits across the cropping systems, it was found that there was a substantial preponderance of σ^2A as compared to σ^2D under both systems. The ratio of σ^2A to

Table 5 Analysis of variance for combining ability for seed yield and its components in different cropping systems

| Source of variation | df | Cropping system | Seed yield/plant | Harvest index | 100-seed weight | Seeds/pod | Pods/plant | Biological yield/plant | Plant height (cm) | Pod bearing branches/plant | Days to 50% flowering | Days to maturity |
|-------------------------|----|-----------------|------------------|---------------|-----------------|-----------|------------|------------------------|-------------------|----------------------------|-----------------------|------------------|
| Replication | 1 | S | 2.19 | 16.64 | 0.07 | 0.38 | 0.64 | 33.66 | 2.39 | 1.1 | 3.01 | 5.50 |
| | | I | 32.30 | 0.39 | 0.005 | 0.02 | 0.037 | 179.44 | 290.92 | 8.27 | 1.77 | 1.25 |
| Lines | 11 | S | 2.26 | 66.63* | 0.09 | 0.25 | 90.18* | 15.31 | 130.23* | 0.83 | 0.43 | 27.36* |
| | | I | 2.86* | 43.24* | 0.43* | 0.44* | 98.84* | 21.70* | 136.21* | 1.41* | 1.07 | 17.03* |
| Testers | 3 | S | 23.54* | 102.09* | 0.35 | 0.10 | 218.02* | 270.69* | 223.40* | 8.08* | 2.39* | 46.93* |
| | | I | 6.23* | 48.12* | 0.13 | 0.10 | 160.02* | 52.67* | 61.07* | 1.73* | 2.42 | 22.47* |
| Lines × Testers | 33 | S | 4.14* | 43.15* | 0.28* | 0.24 | 64.26* | 56.08* | 52.77* | 1.61* | 1.37 | 15.82* |
| | | I | 4.78* | 23.01 | 0.40* | 0.15* | 36.84* | 35.35* | 77.52* | 1.27* | 1.44* | 11.13* |
| Error | 47 | S | 2.12 | 10.69 | 0.18 | 0.20 | 15.38 | 13.90 | 16.59 | 0.72 | 0.98 | 3.91 |
| | | I | 0.87 | 7.34 | 0.12 | 0.07 | 12.31 | 5.64 | 6.74 | 0.58 | 0.99 | 2.98 |
| σ^2_A/σ^2_D | | S | 1.08 | 0.31 | 0.20 | 0.14 | 0.45 | 0.51 | 0.85 | 1.91 | 0.05 | 0.44 |
| | | I | 0.01 | 0.36 | 0.14 | 0.50 | 0.94 | 0.01 | 0.07 | 0.11 | 0.17 | 0.26 |

S, Sole cropping; I, intercropping; *P=0.05

Table 6 Genotypic correlations (r_g) between cropping systems

| Trait | Parent | Cross |
|----------------------------|--------|-------|
| Seed yield/plant (g) | 0.68 | 0.51 |
| Harvest index | 0.49 | 0.59 |
| 100-seed weight | 0.72 | 0.76 |
| Seeds/pod | 0.54 | 0.43 |
| Pods/plant | 0.53 | 0.42 |
| Biological yield/plant (g) | 0.56 | 0.62 |
| Plant height | 0.65 | 0.68 |
| Pod-bearing branches/plant | 0.66 | 0.64 |
| Days to flowering | 0.92 | 0.89 |
| Days to maturity | 0.88 | 0.93 |

σ^2_D decreased with the change from sole cropping to intercropping for majority of the traits, except harvest index, seeds/pod, pods/plant and days to 50% flowering, where it increased.

The present study confirms that the genetic control of important yield-contributing traits was dependent upon the cropping system, which reinforces the conclusions of earlier studies. Whether it was the differential behaviour of genes under 2 cropping systems or the expression of different set of genes across the cropping systems remains an open question. The need for a separate breeding strategy for intercropped urbean was indicated by the poor genotypic correlations between cropping systems for seed yield and its component traits for both parents and their crosses (Table 6). The results are similar to those obtained for intercropping system for seed yield and different yield components and justify separate breeding programmes for each cropping systems (Mohar and Sharma 2006, Mohar 2007 and Sood and Sood 2006).

The present investigation strongly suggests the validity of having separate breeding protocols for improving urbean as a sole and intercrop in respect of seed yield and its components. In sole cropping, where additive variance was substantially higher than non-additive variance, any breeding scheme like single seed descent, the bulk method of breeding and their modifications should be rewarding in getting desirable segregants in the segregating generations. For intercropping, the simultaneous exploitation of additive and non-additive gene action through diallel selective mating may be the most appropriate system for further improved yield.

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