Heterosis in cowpea landraces from Ghana

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SUMMARY

Four crosses involving five local accessions of cowpea were evaluated to determine the amount of heterosis for maturity date, seed yield, and components of yield. Heterosis for seed yield plant^{-1} was greater than that for other characters with a high-parent heterosis of 2.4 to 72.1 per cent. Number of pods plant^{-1} was the most heterotic of the yield components. The cross between high-yielding parents produced the highest heterosis above the mid-parent and high parent for seed yield plant^{-1}. Seed yield may be improved by crossing among local landraces of cowpea through improving the number of pods plant^{-1}.

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RÉSUMÉ

BENNETT-LARTEY, S. O. & OFORI, K.: *L'hétérosis en dolique de landraces du Ghana.* Quatre plantes métisses comprenant cinq nouvelles accessions locales de dolique étaient évaluées pour déterminer le niveau de hétérosis pour la date de maturité, le rendement de graine et les éléments de rendement. L'hétérosis pour le rendement de graine par plante était élevée que celle des autres traits avec un hétérosis parental-élevé de 2.4 à 72.1 pour cent. La quantité de cosses par plante était le plus hétérotique des éléments des rendements. Le croisement entre les parents des rendements élevés produisait l'hétérosis la plus élevée au-dessus de parent-élevé et de parent-moyen pour le rendement de graine par plante. Il paraît que le rendement de graine peut être amélioré par le croisement entre les landraces de dolique locale à travers une amélioration de la quantité de cosses par plante.

Introduction

Cowpea *(Vigna unguiculata* (L.) Walp.) is an important pulse crop in tropical Africa. It is reported to have originated from West Africa (Rachie & Rawal, 1976) and most probably in Nigeria, where wild and weedy species abound (Rachie & Rawal, 1976; Steele, 1976). Cowpea is a cheap source of protein in the diet and an increased production and consumption will help reduce incidence of protein malnutrition especially in children.

Cowpea improvement has been intensified in Ghana since 1979, with the inception of the Ghana Grains Development Project (Asafo-Adjei, 1986). This has led to the release of several improved varieties, notably *Asontem*, *Ayiyi* and *Bengbla.* Crop improvement usually begins with the collection of germplasm which is then characterized and evaluated to determine genetic diversity in the collection. The magnitude of genetic diversity indicates the potential for making improvements through selection or in hybridization programmes. Heterosis indicates some degree of genetic diversity between parents; hence, with increased genetic diversity, high levels of heterosis would be expected. Heterosis, therefore, provides useful information in selecting lines for hybridization.

Most cowpea farmers in Ghana continue to grow local landraces, which may be more adapted to growing conditions than the improved varieties developed. Limited heterotic information is now available for the widely grown local cowpea populations. Agble (1972) observed heterosis for seed size in cowpea among hybrids of four local varieties and suggested that heterosis may be available for other characters in local varieties.

This study aimed at evaluating heterosis of cowpea landrace populations, and identifying crosses with high levels of heterosis that could be used to develop improved varieties with high seed yield.

Materials and methods

The study was carried out at the Plant Genetic Resources Centre, Bunso. Seventy-one accessions of cowpea were collected from four cowpea-growing regions of Ghana, namely, Northern, Upper East, Upper West, and Eastern Regions, from October to December 1987. Seeds from these accessions were sown in the field in October 1988 for seed multiplication, characterization, and preliminary evaluation. There was one row of each accession. The rows were spaced at 90 cm apart and the plants were 60 cm apart within a row. There was one plant per stand and each row was 6 m long.

Forty-five accessions, which had sufficient seed from the previous year's multiplication, were selected for further characterization and evaluation in April 1989. One-row plots were used with rows being 60 cm apart and plants within a row being 30 cm apart. There were two plants per hill. The recommended rate of 50 kg of P_2O_5 fertilizer per hectare was applied at time of planting (GGDP, 1989).

Based on differences in seed yield and components of seed yield from the 1989 study, five accessions were selected to study heterosis for seed yield and its components. Table 1 shows the characteristics of the parental accessions. A single row of each accession was grown at different times to synchronize flowering periods. Planting was done in April 1990. The following four crosses were made to establish four F_1 populations: I. 87 - 56 × 87 - 94, II. 87 - 35 × 87 - 157, III. 87 - 27 × 87 - 35, and IV. 87 - 27 × 87 - 157. Crosses I and IV involved fairly similar parents while Crosses II and III involved dissimilar parents with respect to seed yield per plant. Reciprocal crosses were made according to the method

TABLE 1

Maturity Dates, Seed Yield and Components of Seed Yield of Parental Accessions

Accession	*Days to maturity*	*Pods plant^{-1}*	*Seeds pod^{-1}*	*100-seed weight (g)*	*Seed yield plant^{-1} (g)*
87 - 27	67	32.0	16.1	11.8	46.9
87 - 35	69	14.7	8.1	15.2	17.9
87 - 56	57	28.3	11.3	9.6	29.1
87 - 94	60	23.3	12.3	10.7	28.2
87 - 157	66	44.7	15.6	9.3	36.9

developed at the International Institute of Tropical Agriculture (IITA) (Rachie & Rawal, 1976). Mature pods were harvested as soon as they began to dry and turned colour completely.

In August 1990, the parents and the four F_1 hybrids were planted in a randomized complete block design with three replications. Three-row plots were used with each plot measuring 1.8 m × 2.1 m. The rows were 60 cm apart and the plants spaced at 30 cm apart within a row. Three seeds per hill were sown and thinned out to two plants per hill at 1 week after emergence. There were two manual weedings at 2 weeks after emergence and 3 weeks later. Pre-flowering insects were controlled with Cymbush 2.5 E C (cypermethrin) at 50 g a. i. ha^{-1} at budding stage. Roxion (dimethoate) at 400 g a. i. ha^{-1} was sprayed to control post-flowering insects at the early podding and pod-filling stages.

Data were collected by using the five central hills of each middle row of a plot. Only one plant from each hill was used to collect data as follows: days to flowering; days to maturity; pods per plant; pod length, using 10 randomly selected pods per plant; seeds per pod, using 10 randomly selected pods per plant; 100-seed weight (g) from the average of three batches of 100 seeds from bulk seeds from each plot; and grain yield per plant. Percent mid-heterosis and higher parent heterosis (heterobeltiosis) were calculated as follows:

Heterosis (percent) = $[(F_1 - MP)/ MP] \times 100$ and

Heterobeltiosis (percent) = $[(F_1 - HP)/HP] \times 100$

where F_1, MP and HP are the means for the F_1, mid-parent, and higher parent (El-Hosary & Nawar, 1984; Quendeba *et al.*, 1993). Tests of significance of heterosis were determined by using t-test.

Results

Table 2 presents means of seed yield and components of seed yield of parental accessions and their F_1 hybrids. Both mid-parent and high parent heterosis or heterobeltiosis varied among the four crosses. The F_1s from all crosses were not significantly different from their mid-parent values for days to maturity. In Crosses II and III, the hybrids were significantly ($P<0.05$) later than their earlier maturing parents.

Percent mid-parent heterosis for the number of pods plants^{-1} ranged from 34.2 to 82.4. Two of the Crosses (II and III) showed significantly ($P<0.05$) high-parent heterosis and had 57 to 60 per cent more pods plant^{-1} than the better parents. Percent heterosis for seeds pod^{-1} and 100-seed weight were low for all crosses. The seeds pod^{-1} of the F_1s for three out of four crosses were lower than that of their higher parents.

The heterotic values for seed yield plant^{-1} varied considerably among the crosses, and were generally higher than those observed for the components of seed yield. Percent heterosis was significant in all crosses. The cross between the high-yielding parents, 87-27 and 87-157 (Cross IV), produced the highest percent heterosis. Crosses II and III, which involved low-yielding and high-yielding parents, produced significant mid-parent and high-parent heterosis. For Cross I, where the parents were similar in seed yield plant^{-1}, percent heterosis was significant ($P<0.05$), but heterobeltiosis was not.

TABLE 2

Average Performance of Parental and F_1 Generations and Percent Heterosis for Four Crosses of Cowpea Landraces

				Heterosis (%)	
Cross	P_1	P_2	F_1	Mid-parent	Higher-parent
Days to maturity					
I (87-56 × 87-94)	66	68	66	-1.5	0.0
II (87-35 × 87-157)	56	70	64	-1.6	14.3*
III (87-27 × 87-35)	56	66	64	4.9	14.3*
IV (87-27 × 87-157)	58	66	61	-1.6	5.2
Pods plant^{-1}					
I (87-56 × 87-94)	24.7	14.2	26.1	34.2*	5.7
II (87-35 × 87-157)	18.2	15.2	29.1	74.8**	59.9**
III (87-27 × 87-35)	23.2	23.1	36.5	57.7**	57.3**
IV (87-27 × 87-157)	15.4	40.3	50.8	82.4**	26.1*
Seeds pod^{-1}					
I (87-56 × 87-94)	14.7	8.0	11.4	0.4	-22.5*
II (87-35 × 87-157)	16.4	8.2	10.5	-14.6	-36.0*
III (87-27 × 87-35)	11.8	13.5	13.0	2.8	-3.7
IV (87-27 × 87-157)	15.8	15.6	16.7	6.4	5.7
100-seed weight (g)					
I (87-56 × 87-94)	10.1	15.9	12.8	-1.5	-19.5
II (87-35 × 87-157)	12.3	15.6	16.6	19.0	6.4
III (87-27 × 87-35)	9.6	10.8	11.4	11.8	5.6
IV (87-27 × 87-157)	11.4	8.6	10.9	9.0	-4.4
Seed yield plant^{-1}					
I (87-56 × 87-94)	37.2	17.9	38.1	38.3*	2.4
II (87-35 × 87-157)	36.9	19.0	51.2	83.2**	38.8*
III (87-27 × 87-35)	26.1	33.6	54.2	81.6**	61.3**
IV (87-27 × 87-157)	27.0	54.2	93.3	129.8**	72.1**

Discussion

The amount of heterosis varied among the crosses for the characters studied. The significant high- or better-parent heterosis for pods per plant and seed yield plant^{-1} for some crosses indicates the usefulness of these hybrid populations. The high heterosis of Crosses II, III, and IV for these two characters indicates that the parental accessions are genetically more diverse than landraces with low heterosis, such as in Cross I. Cross IV (87-27 × 87-157) involving the high-yielding parents produced the highest mid-parent and high-parent heterosis of about 72 and 130 per cent, respectively. Selection for such a population would ensure rapid progress in the development of hybrids (Baker, 1978). The high heterosis also indicated high combining ability. However, this may not be true for all crops, nor for all population's of a given crop (Liang, Reddy & Dayton, 1972).

The high heterosis of seed yield relative to components of seed yield is expected, since seed yield is a product of these components. According to Grafius (1964), yield increases do not necessarily result from changes in yield components, but any change in yield must be accompanied by a change in one or more of the components. Hathcock & McDaniel (1973) found that seed yield increases could be large without high-parent heterosis for any component of seed yield in oat hybrids.

The number of pods per plant showed the greatest and most consistent heterotic values among components of yield, and contributed most to seed yield heterosis. Kheradnam, Bassiri & Niknejad (1975) studied a cowpea cross with parents differing in several characters. The greatest mid-parent heterosis was for seed yield, but pods per plant and pods per peduncle also had significant high-parent heterosis. In a study on heterosis involving local cowpea landraces, Agble (1972) observed significant mid-parent heterosis for seed size in four out of 10 crosses. Seed size was lower in the F_1 than in the mid-parent value in three of the crosses; hence, it showed negative heterosis. However, Agble (1972) suggested that seed size and other characters might be improved by crossing between local varieties. In this study, mid-parent and high-parent heterosis were not significant for 100-seed weight. The results of seed yield per plant in this study have shown that there is the potential to improve seed yield, largely through improving the number of pods per plant.

REFERENCES

Agble, F. (1972) Seed size heterosis in cowpea. *Ghana J. Sci.* **12,** 30-33.

Asafo-Adjei, B. (1986) Cowpea improvement program: Ghana Grains Development Project. *Trop. Grain Legume Bull.* **32,** 103-109.

Baker, R. J. (1978) Issues in diallel analysis. *Crop Sci.* **18,** 533-536.

El-Hosary, A. A. & Nawar, A. A. (1984) Gene effects in field beans (*Vicia faba* L.): Earliness and maturity. *Egypt J. Genet. Cytol.* **13,** 109-119.

GGDP (1989) *Maize and cowpea production guide for Ghana.* Ghana/CIDA Grains Development Project, January 1990.

Grafius, J. E. (1964) A geometry for plant breeding. *Crop Sci.* **4,** 241 - 246.

Hathcock, B. P. & McDaniel, M. E. (1973) Yield and yield component heterosis in *Avena* hybrids. *Crop Sci.* **13,** 8-10.

Kheradnam, M., Bassiri, A. & Niknejad, M. (1975) Heterosis, inbreeding depression and reciprocal effects for yield and some yield components in a cowpea cross. *Crop Sci.* **15,** 689-691.

Liang, G. H., Reddy, C. R. & Dayton, A. D. (1972) Heterosis, inbreeding depression and heritability estimates in a systematic series of grain sorghum genotypes. *Crop Sci.* **12,** 409-411.

Quendeba, B., Ejeta, G., Nyquist, W. E., Hanna, W. W. & Kumar, A. (1993) Heterosis and combining ability among African pearl millet landraces. *Crop Sci.* **33,** 735-739.

Rachie, K. O. & Rawal, K. M. (1976) Integrated approaches to improving cowpeas. *Tech. Bull.* **5.** IITA, Ibadan, Nigeria.

Steele, W. M. (1976) Cowpeas. In *Evolution of crop plants* (ed. N.W. Simmonds), pp. 183-185. London, Longman.