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# USE OF MALE STERILITY TO MEASURE HETEROSIS IN PIGEONPEA (*CAJANUS CAJAN* L. MILLSP.)

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## ABSTRACT

**The hybrids developed with three genetic male sterile lines, MS 3A, MS 4A and MS Prabhat, using twenty diverse pollinators were evaluated. A large number of hybrids depicted significant and useful heterosis over better parent and standard variety, BDN 2, for seed yield per plant which was due to high heterosis for pods per plant, plant height and branches per plant. Such hybrids were early in maturity with reduced plant height. Heterosis for seed yield over better parent was highest in the cross MS 3A x DL 78-1 ((79.9%), followed by MS Prabhat x ICPL 384 (78.2%). In respect of superiority over the cultivated variety BDN 2, the crosses MS 3A x IPCL 8504 (74.9 %), MS 4A x B 12 (40.7 %), and MS 3 A x ICPL 6997 (35.1) were the three best hybrids. The hybrids involving both the early parents were superior for early maturity but not for seed yield. The high heterotic hybrids involved at least one medium duration parent.**

**Key words:** Pigeonpea, heterosis, genetic male sterility.

Heterosis has been extensively used to realise substantial gains in yield levels in crops like maize, sorghum, bajra, cotton and castor. Considerable extent of heterosis for yield and other traits has also been reported in many legumes [1], including pigeonpea [2–4]. The identification of two genetic male sterility systems in pigeonpea [5, 6] coupled with high degree of natural outcrossing reported by several workers [7] and utilization of these avenues in producing and testing experimental hybrids [2–4, 8] have opened possibilities of developing commercial hybrids in pigeonpea. Attempts have also been made [3, 4, 9] to develop and standardize economical hybrid seed production technology. In this paper, the results on the extent of heterosis for seed yield and its component traits in pigeonpea hybrids based on male sterile lines are reported.

## MATERIALS AND METHODS

The male sterile sibs of each of the three genetic male sterile lines, MS 3A, MS 4A

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(medium duration indeterminate) and MS Prabhat (short duration determinate), were hand-pollinated using the pollen from ten medium and ten short duration pollinators. The resultant sixty hybrids along with 23 parents were evaluated during kharif 1985-86 in randomized block design replicated thrice. Seeds of fertile sibs of each male sterile line were used for growing female parents in the experiment. Seeds of each entry were dibbled in two rows each of 3 m length with 75 x 25 cm spacing. The crop was raised following the recommended package of practices. The observations on five randomly selected plants were recorded for five characters, except for days to maturity, which was recorded as number of days from date of sowing till about 80% of plants in a plot reached pod picking stage. The standard procedure of analysis of variance for the experimental design was adopted to detect genetic differences among treatments, hybrids and parents. This was followed by estimation of heterosis over better parent (BP) and standard check variety, BDN 2 (SH) [10].

## RESULTS AND DISCUSSION

The range of BP heterosis in 60 hybids and SH over BDN 2 was considerable for all the traits, except for days to maturity (Table 1). As many as 24 and 22 hybrids depicted significant and positive BP heterosis and SH over BDN 2, respectively, for seed yield, of which 20 and 14 hybrids recorded more than 20% heterosis. The frequency of hybrids exhibiting significantly positive and more than 20% heterosis were even more for pods/plant (22% and 40%) over both parents and for branches/plant (28%) over BDN 2. The hybrids showing desirable heterosis were fewer for days to maturity. Only two hybrids recorded significantly negative BP heterosis for plant height. Out of the 60 hybrids tested, significant SH over BDN 2 for seed yield was noted in 22 hybrids only (Table 1). It was observed that their BP heterosis for seed yield was also significant in all but three cases. Maximum BP heterosis (79.9%) was observed in the cross MS 3A x DL 78-1, followed by MS

**Table 1. Range of heterosis and number of hybrids with significant BP heterosis and SH over cv. BDN 2 for five characters in pigeonpea**

| Character | Range of heterosis (%) over | | Hybrids with significant heterosis over | | | |
|---|---|---|---|---|---|---|
| | BP | BDN 2 | BP | | BDN 2 | |
| | | | 10% | 20% | 10% | 20% |
| Seed yield/plant | –30.7–79.8 | –50.1–74.9 | 4 | 20 | 8 | 14 |
| Days to maturity* | –17.0–26.2 | –23.9–23.7 | 1 | 9 | 14 | 6 |
| Plant height* | –9.7–76.1 | –13.7–50.3 | — | 2 | — | — |
| Branches/plant | –43.[illegible]–102.7 | –26.0–102.7 | 3 | 7 | 11 | 28 |
| Pods/plant | –74.9–116.1 | –3.8–161.5 | 9 | 22 | 3 | 40 |

*For days to maturity and plant height, the parent with low score was considered as the better parent.

Prabhat x ICPL 384 (78.2%). As regards to SH over BDN 2, MS 3A x ICPL 8504 (74.9%), MS 4A x B 12 (40.7%) and MS 3A x ICPL 6997 (35.1%) were the three best hybrids. High degree of heterosis for seed yield in pigeonpea is reported by several workers [2, 4, 8, 11–14]. All the hybrids with significant BP heterosis and SH for seed yield were associated with significant and positive BP heterosis for plant height and pods/plant, except MS 4A x B 12 which showed negative value for plant height. This was also true for heterosis over BDN 2 for branches/plant in 17 out of 22 hybrids. High degree of heterosis for pods/plant [2, 4, 11], branches/plant [4, 11, 12] and plant height [12] has been previously repor- ted. The high heterotic response for seed yield in the present study may be attributed to high mani- festation of heterosis in the component char- acters like pods/plant, plant height and branches/plant. For days to maturity, signifi- cant negative BP heterosis and SH over BDN 2 was observed in 9 and 7 hybrids, respectively.

**Table 2. Mean performance ($\bar{X}$), BP heterosis, SH**

| Hybrid | Seed yield/plant (g) | | | Days to maturity | | |
|---|---|---|---|---|---|---|
| | $\bar{X}$ | BP | SH | $\bar{X}$ | BP | SH |
| MS Prabhat x T 15-15 | 62.8 | -8.3 | 29.8** | 128.7 | -4.69** | -16.81** |
| MS Prabhat x ICPL 8504 | 56.2 | -16.5** | 16.2** | 144.7 | 7.16** | -6.47** |
| MS Prabhat x Hy 3A | 57.4 | 76.2** | 18.6** | 143.3 | 6.17** | -7.33* |
| MS Prabhat x AGS 498 | 54.7 | 7.6 | 12.1* | 135.0 | 0.00 | -12.72** |
| MS Prabhat x ICPL 384 | 58.2 | 78.2** | 20.2** | 145.0 | 7.41** | -6.25** |
| MS 3A x B 12 | 58.7 | 45.3** | 21.4** | 156.0 | -1.27 | 0.86 |
| MS 3A x ICPL 6997 | 65.4 | 27.6** | 35.1** | 158.7 | -7.93** | 2.59** |
| MS 3A x ICPL 8504 | 84.6 | 25.7** | 74.9** | 159.3 | -6.82** | 3.02** |
| MS 3A x ICPL 7979 | 62.9 | 10.0** | 30.0** | 162.7 | -5.61** | 5.17** |
| MS 3A x ICPL 87 | 59.8 | 70.9** | 23.6** | 154.7 | 17.77** | 0.00** |
| MS 3A x GAUT 82-55 | 54.9 | 29.1** | 13.5** | 158.0 | 3.72** | 2.05** |
| MS 3A x ICPl 384 | 59.4 | 69.8** | 22.9** | 168.3 | -1.94** | 8.84** |
| MS 3A x T 21 | 58.5 | 60.7** | 20.8** | 156.0 | 18.18** | 0.86 |
| MS 3A x DL 78-1 | 62.9 | 79.9** | 30.1** | 129.3 | 13.78** | -23.92** |
| MS 4A x T 15-15 | 63.9 | 6.7 | 32.1** | 161.3 | -4.16** | 4.31** |
| MS 4A x B 12 | 68.1 | 68.4** | 40.7** | 155.3 | -1.69** | 0.43 |
| MS 4A x ICPl 8504 | 59.9 | -11.0* | 23.8** | 161.7 | -3.96** | 4.53** |
| MS 4A x ICPL 7979 | 72.8 | 27.2** | 39.4** | 169.7 | -0.79 | 9.70** |
| MS 4A x AGS 498 | 57.2 | 12.5** | 18.2** | 159.3 | -5.35** | 3.02** |
| MS 4A x AGS 521 | 57.0 | 46.1** | 17.9** | 163.0 | -0.81 | 5.39** |
| MS 4A x GAUT 82-53 | 56.1 | 43.9** | 16.0** | 158.3 | -1.45 | 23.71** |
| MS 4A x UPAS 120 | 54.6 | 40.0** | 12.9** | 132.0 | 5.32** | -14.66** |
| BDN 2 | 48.4 | — | — | 154.7 | — | — |
| SE | 2.20 | 2.9 | 2.9 | 0.9 | 1.29 | 1.29 |

The 60 hybrids were divided into 6 groups based on maturity of their parents (Table 3). Cross between early parents (E x E) mostly resulted into early hybrids but had little advantage for seed yield and other traits except pods per plant. The maximum number of hybrids showing beneficial heterosis for yield and other traits involved one or both medium maturing parent(s), indicating possible advantage of using at least one medium duration parent for developing promising hybrids.

**(over BDN 2) in pigeonpea hybrids for five characters**

| Plant height (cm) | | | Branches/plat | | | Pods/plant | | |
|---|---|---|---|---|---|---|---|---|
| $\bar{X}$ | BP | SH | $\bar{X}$ | BP | SH | $\bar{X}$ | BP | SH |
| 127.3 | 23.0** | 24.4** | 9.0 | –0.18** | 0.0 | 300.0 | 30.2** | 110.5** |
| 136.9 | 32.2** | 33.8** | 10.9 | –6.66 | 21.0** | 275.3 | 14.0** | 101.5** |
| 128.1 | 23.7** | 25.2** | 7.9 | 0.00 | –12.4 | 221.4 | 27.7** | 62.0** |
| 131.3 | 26.8** | 28.3** | 9.3 | 7.69 | 3.7 | 240.7 | 33.8** | 76.1** |
| 123.1 | 18.8** | 20.3** | 11.6 | 46.53** | 28.4** | 278.2 | 60.4** | 103.6** |
| 132.2 | 4.9* | 29.2** | 11.2 | 1.02 | 24.7** | 211.3 | 43.9** | 54.6** |
| 135.2 | 7.3** | 32.1** | 10.6 | –5.01 | 17.3** | 293.0 | 99.5** | 114.4** |
| 136.0 | 7.9** | 32.9** | 12.0 | 2.84 | 33.4** | 357.3 | 47.9** | 161.5** |
| 137.9 | 14.0** | 34.7** | 10.9 | –1.98 | 21.0* | 244.7 | 57.8** | 79.0** |
| 130.8 | 76.1** | 27.8** | 8.7 | –21.99** | –3.7 | 198.6 | 35.2** | 45.3** |
| 128.3 | 24.6** | 25.4** | 14.4 | 30.00** | 60.6** | 182.3 | 24.1** | 33.4** |
| 128.0 | 2.0 | 25.1** | 12.9 | 15.99** | 43.2** | 192.0 | 30.7** | 40.5** |
| 138.2 | 34.0** | 35.1** | 12.1 | 8.91 | 34.4** | 246.7 | 35.2** | 80.5** |
| 126.4 | 46.8** | 23.6** | 10.9 | –2.01 | 21.0** | 290.2 | 68.7** | 112.4** |
| 128.9 | 1.6 | 25.9** | 13.6 | 2.62 | 50.6** | 232.2 | 0.8 | 69.9** |
| 133.7 | –3.6 | 30.6** | 12.6 | –4.95 | 39.5** | 331.7 | 116.1** | 142.7** |
| 133.1 | –4.0 | 30.1** | 13.4 | 1.77 | 49.4** | 212.9 | 38.7** | 55.8** |
| 130.6 | 7.9** | 27.6** | 14.4 | 9.24 | 60.0** | 246.6 | 59.1** | 80.4** |
| 141.1 | 21.7** | 37.9** | 13.3 | 0.93 | 48.1** | 282.7 | 84.2** | 106.8** |
| 152.1 | 30.3** | 48.6** | 12.8 | –3.28 | 42.0** | 241.7 | 57.5** | 76.8** |
| 124.3 | 6.5** | 21.0** | 14.6 | 10.17 | 62.2** | 193.1 | 25.8** | 30.2** |
| 123.9 | 33.5** | 21.1** | 10.1 | –23.44** | 12.4 | 213.0 | 38.8** | 55.8** |
| 102.3 | — | — | 9.0 | — | — | 136.7 | — | — |
| 2.2 | 3.2 | 3.2 | 0.8 | 0.78 | 0.8 | 9.3 | 11.6 | 11.6 |

The substantial hybrid vigour available in several hybrids suggests that hybrid breeding programme could profitably be undertaken in this crop. With the availability of male sterility systems, high degree of natural outcrossing and technology for large scale hybrid seed production, highly heterotic hybrids can be channelised in hybrid breeding programme. The genetic male sterility system causes some inefficiency in hybrid seed production, especially roughing out of 50% fertile sibs in female rows before they shed pollen. However, the markers like translucent anthers [5] and arrow-head shaped brown anthers [6] associated with male sterility systems permit easy and prompt way of identi- fication of sterile sibs using unopened bud(s) with the initiation of reproductive phase. Since the hybrids in the present study are tested in smaller plots in a single environment, their large scale evaluation in large plots over a range of environments would be helpful in deciding their stability in performance and heterotic response as well as prospects for commercial cultivation.

**Table 3.** Frequency of hybrids with significant heterosis in various maturity groups for different characters

| Type of cross | Female parent | Total crosses | Seed yield per plant | Days to maturity | Plant height | Branches per plant | Pods per plant |
|---|---|---|---|---|---|---|---|
| | | Heterosis over better parent | | | | | |
| Early x Early | MS (Prabhat) | 10 | 0 | 6 | 0 | 3 | 5 |
| Early x Medium | MS (Prabhat) | 10 | 3 | 4 | 0 | 3 | 7 |
| Medium x Early | MS 3A | 10 | 8 | 1 | 0 | 2 | 9 |
| Medium x Early | MS 4A | 10 | 4 | 0 | 2 | 0 | 6 |
| Medium x Medium | MS 3A | 10 | 5 | 8 | 0 | 0 | 5 |
| Medium x Medium | MS 3A | 10 | 4 | 7 | 1 | 0 | 0 |
| | | Heterosis over BDN 2 | | | | | |
| Early x Early | MS (Prabhat) | 10 | 0 | 10 | 2 | 1 | 9 |
| Early x Medium | MS (Prabhat) | 10 | 5 | 10 | 0 | 5 | 9 |
| Medium x Early | MS 3A | 10 | 5 | 3 | 0 | 7 | 9 |
| Medium x Early | MS 4A | 10 | 2 | 5 | 0 | 5 | 8 |
| Medium x Medium | MS 3A | 10 | 4 | 1 | 0 | 6 | 7 |
| Medium x Medium | MS 4A | 10 | 6 | 0 | 0 | 8 | 8 |

## REFERENCES


1. K. B. Singh. 1974. Exploitation of heterosis in pulse crops. Indian J. Genet., **34**: 752–756.

2. K. B. Saxena, D. G. Faris, L. J. Reddy, D. Sharma, B. V. S. Reddy, S. C. Gupta and J. M. Green. 1986. Prospects for hybrid pigeonpeas. Proc. V. Intern. Congr. SABRAO (eds. B. Napompeth and S. Sabhadrabandhu). Faculty of Agriculture, Kasetsart University, Bangkok, Thailand: 379–388.

3. K. B. Saxena, Y. S. Chauhan, C. Johansen and L. Singh. 1989. Recent developments in hybrid pigeonpea. Abstr. National Symp. New Frontiers in Pulses Research and Development. Directorate of Pulses Research, Kanpur: 26.

4. P. P. Zaveri, A. R. Pathak, G. V. Patel, J. A. Patel, L. K. Dhaduk, H. R. Kher, R. M. Shah and P. S. Bharodia. 1989. Genetic studies in relation to pigeonpea hybrids based on male sterile lines. Abstr. National Symp. New Frontiers in Pulses Research and Development. Directorate of Pulses Research, Kanpur: 41.

5. B. V. S. Reddy, J. M. Green and S. S. Bisen. 1978. Genetic male sterility in pigeonpea. Crop Sci., **18**: 362–364.

6. K. B. Saxena, E. S. Wallis and D. E. Byth. 1983. A new gene for male sterility in pigeonpea (*Cajanus cajan* (L.) Millsp.). Heredity, **51**: 419–421.

7. K. B. Saxena, L. Singh and M. D. Gupta. 1990. Variation for natural outcrossing in pigeonpea. Euphytica, **46**: 143–148.

8. S. C. Gupta, L. J. Reddy and D. G. Faris. 1983. Early maturity pigeonpea hybrids. Intern. Pigeonpea Newsl., **2**: 19–20.

9. K. B. Saxena, S. C. Gupta, R. V. Kumar, L. J. Reddy, L. Singh and D. G. Faris. 1989. ICPH 8—the first promising, short duration pigeonpea hybrid. Intern. Pigeonpea Newsl., **9**: 8–10.

10. P. F. Zaveri, R. M. Shah, A. R. Pathak, J. A. Patel, H. R. Kher, R. S. Patel and S. B. S. Tikka. 1985. BDN 2—a wilt tolerant superior cultivar of pigeonpea for Gujarat. Intern. Pigeonpea Newsl., **1**: 9–10.

11. M. P. Shrivastava, L. Singh and R. P. Singh. 1976. Heterosis in pigeonpea. Indian J. Genet., **36**: 197–200.

12. R. V. Marekar. 1981. Heterosis in pigeonpea. Res. Bull. Marathwada Agril. Univ., **5**: 33–38.

13. P. Omanga. 1984. The use of male sterile lines to measure the nature and magnitude of hybrid vigour in pigeonpea. Proc. Symp. Dryland Farming Research. Nairobi, Kenya: 14–17.

14. D. B. Patel. 1985. Heterosis and Combining Ability in Pigeonpea. M. Sc. Thesis. Gujarat Agricultural University, Sardar Krushinagar, Gujarat.