**TO STUDY THE MAGNITUDE OF HETEROSIS FOR YIELD AND IT'S COMPONENTS** **IN PIGEON PEA [*Cajanus cajan* (L.) Millsp.]**

**Abstract**

The six genotypes were crossed in a half diallel fashion and 15 F1's were obtained. All the crosses and their parents along with check were sown in randomized block design with three replications during *Kharif-*2023. The observations on eleven characters were recorded. Comparison of mean squares due to parents *vs*. hybrids was found to be significant for pods per plant, seeds per pod, seed yield per plant, 100 seed weight and protein content. This implied that the performance of parents were different than that of hybrids, which revealed the presence of mean heterosis for almost all the characters studied. The characters with favourable heterosis over better parent in more number of crosses were pod length (11), pods per plant (09), primary branches per plant (08), days to 50% flowering (07), days to maturity (07), plant height (06), secondary branches per plant (05) and seed yield per plant (05), whereas less number of crosses were observed for seeds per pod, 100 seed weight, protein content with favourable heterobeltiosis. Among the hybrids, BP-16-184 x NP-09-30, UPAS-120 x NP-09-30, NP-09-26 x NP-09-30 and BDN-711 x NP-09-26 were found to be the most heterotic cross combinations for seed yield per plant and yield attributing traits

**Keywords**

Pigeon pea, Heterosis, Hybrid, Seed yield

**Introduction**

Pigeon pea is one of the major pulse crops of dry land agriculture due to its deep tap root system and inherent drought resistance. The ability of pigeon pea to produce high amount of biomass per unit area makes it useful as fodder, fuel and for thatching for the rural masses. Being legume, it has symbiotic association with *rhizobium* which plays an important role in fixing atmospheric nitrogen upto 20-40 kg/ha for which pigeon pea is inevitable part of various cropping system (Singh, 2003).

Pigeon pea [*Cajanus cajan* (L.) Millsp.] is the sixth most important legume crop globally (FAO, 2015), grown predominantly in the tropical and sub-tropical regions of Asia, Africa and Latin America. It is a most versatile food legume with diversified uses as food, feed, fodder and fuel. It is commonly known as “*Arhar*” or *“Tur*”, generally used in preparing *dal*, which is fairly rich in protein and minerals and eaten by the majority of Indian population.

In India, pigeon pea is planted in about 4.80 million hectares of land and it occupies first position in production with 36.66 lakh tonnes with productivity of 900 kg/ha among all pigeon pea producing countries in the world (Annon. 2023a). In Gujarat pigeon pea is planted 2.46 lakh hectares with production of 2.86 lakh tonnes and productivity of 1164 kg/ha (Annon. 2023b).

The magnitude of heterosis serves as guide for the choice of desirable parents and is also a basis for determining the genetic diversity (Swindell and Poehlman, 1976). Yield improvement can be achieved by exploitation of heterosis and hybrid vigor in pigeon pea by considerable additive and non-additive gene action in heterosis breeding (Saxena and Sharma, 1990).

**Material and methods**

The crossing programme was carried out during Kharif-2022 at National Agricultural Research Project, College of Agriculture, NAU, Bharuch. The 15 crosses made using 6 diverse parents *viz*., BP-16-184, UPAS-120, BP-22-07, BDN-711, NP-09-26 and NP-09-30 of pigeon pea in half diallel mating design. A complete set of 22 entries comprising of six parental genotypes, their 15 hybrids and one standard check variety (GT-105) were evaluated in Randomized Block Design (RBD) with three replications during *Kharif*-2022. Each entry was grown in a single row plot of 3 m length. Fifteen plants in each row were accommodated keeping 20 cm inter-plant distance while inter-row distance was kept 90 cm. Five plants were randomly selected and tagged excluding border plants from each replication. All the cultural and recommended package of practices in vogue on the farm was followed. Observations were recorded on the 11 characters *viz.,* Days to 50% flowering, Days to maturity, plant height (cm), primary branches per plant, secondary branches per plant, pods per plant, pod length (cm), seeds per pod, seed yield per plant (g), 100 seed weight (g), and protein content (%). The heterotic effects were computed as the percentage increase or decrease of F1 mean values over the better parent (Heterobeltiosis) and standard check variety (standard heterosis) for all the characters and crosses following the standard formula.

**Result and discussion**

In present study, the magnitude of the heterosis varied from cross to cross and character to character. The top cross combinations BP-16-184 x NP-09-30, UPAS-120 x NP-09-30, NP-09-26 x NP-09-30 and BDN-711 x NP-09-26 reported higher seed yield per plant. They also showed significant and desirable heterosis over better parent and standard check for various characters (Table 1). The top cross combination BP-16-184 x NP-09-30 showed significant heterosis in desirable direction for different traits over better parent and standard check *viz.*, days to 50% flowering, days to maturity, plant height, pods per plant, pod length, seeds per pod, seed yield per plant and 100 seed weight.

While second best cross UPAS-120 x NP-09-30 showed significant heterosis in desirable direction for different traits over better parent and standard check *viz.,* plant height, primary branches per plant, secondary branches per plant, pods per plant, pod length, seeds per pod, seed yield per plant and 100 seed weight. Third rank cross, NP-09-26 x NP-09-30 showed significant heterosis in desirable direction for different traits over better parent and standard check *viz.,* plant height, primary branches per plant, pods per plant, pod length, seeds per pod, seed yield per plant and 100 seed weight. Whereas fourth best cross, BDN-711 x NP-09-26 showed significant heterosis in desirable direction for different traits over better parent and standard check *viz.,* primary branches per plant, pods per plant, seeds per pod, seed yield per plant, 100 seed weight and protein content (Table 1).

Interestingly it was further observed that out of the four most economic crosses, parent NP-09-30 was involved as common parent in three crosses and NP-09-26 was involved as common parent in two crosses which indicated their superiority over rest of the parents. . All the best four hybrids depicted significant positive SCA effects for seed yield per plant indicating involvement of non-additive gene action in the heterotic response of these hybrids. The predominance of non-additive gene action in the expression of seed yield per plant was also reported by Arbad *et al.* (2013) Pandey *et al.* (2014), Tikle *et al.* (2016), Yamanura *et al*. (2016), Marawar *et al.* (2018), Boratkar *et al.* (2019), Patel *et al.* (2020b) and Savaliya *et al.* (2023).

**References**

Anonymous (2023a), Ministry of Agricultural and farmers welfare, Govt. of India Retrived from https://eands.dacnet.nic.in/ [Accessed 29 January,2024]

Anonymous (2023b). DES, GoI, Min. of Agri. & FW (DA&FW) Retrieved from [Crop-wise Area, Production and Productivity of Pulses from 2017-18 to 2021-22.pdf (dpd.gov.in)](https://dpd.gov.in/Crop-wise%20Area,%20Production%20and%20Productivity%20of%20Pulses%20from%202010-11%20to%202020-21.pdf) [Accessed 5 march, 2024]

Arbad, S. K.; Madrap, I. A. and Jadhav, P. (2013). Combining ability for yield and yield contributing characters in pigeon pea. Int. J. Agric. Sci., 9 (1): 252-2

Boratkar, M. V.; Bhivgade, S. W.; Hivrale, D. S. and Patil, A. N. (2019). Estimation of combining ability for yield and yield attributing traits in pigeon pea [*Cajanus cajan* (L.) Millsp.]. *Int. J. Recent Sci. Res.,* **10** (10): 35527-35529.

FAO (2015). Food and agriculture data. http://www.fao.org/economic/ess/en

Marawar, M. W.; Mhasal, G. S. and Tayade, S. D. (2018). Line × Tester analysis in new experimental CMS based pigeon pea hybrids. Int. J. Curr. Microbiol. App. Sci., 6: 2072-2078.

Pandey, P.; Tiwari, Yamanura, Y.; Muniswamy, S. and Ramesh, R. (2016). Implications of hybrid vigour, combining ability and *per se* performance in pigeon pea [*Cajanus cajan* (L.) Millsp.]. *J. Appl. Nat. Sci.*, **8** (2): 597-603.

D.; Pandey, V. R. and Yadav, S. (2014). Studies on gene action and combining ability of cytoplasmic-genic male sterile hybrids in pigeon pea [*Cajanus cajan* (L.) Millsp.].  *Aust. J. Crop Sci.*, **8(**5): 814-821.

Savaliya, D.; Chandramaniya, C.; Parmar, M.; Suthar, M. C.; Tamboli, N.; Patel, H. H. and Chauhan, D. A. (2023). Heterosis and combining ability study in hybrids developed from A2 cytoplasm of *cajanus scarabaeoides* in pigeon pea. *Biol. Forum*., **15** (12): 69-74.

Saxena, K. B.; and Sharma, D. (1990). Pigeon pea genetics. In: The pigeon pea, Nene YL, Hall SD and Sheila VK (Eds). *CAB International, Wallingford, Oxon*, UK pp. 137-158.

Singh, C. 2003. Modern technique of raising field crops. Oxford and IBM Publishing Co. Pvt. Ltd. 2" Edn. pp 229-230.

\*Swindell, R. E. and Poehlman, J. M. (1976). Heterosis in the mungbean (*Vigna radiata* (L.) Wilezek). *Tropical Agriculture*, **53**: 25-30.

Tikle, A. N.; Sameer Kumar, C. V.; Vijay Kumar, R. and Saxena, K. B. (2016). Gene action and combining ability estimates using cytoplasmic-genic male sterile lines to develop pigeon pea hybrids for rainfed condition. *Int. J. Sci. Res. Publ.*, **6** (1): 502-506.

Yamanura, Y.; Muniswamy, S. and Ramesh, R. (2016). Implications of hybrid vigour, combining ability and *per se* performance in pigeon pea [*Cajanus cajan* (L.) Millsp.]. *J. Appl. Nat. Sci.*, **8** (2): 597-603.

-------------------------------------------------------------------------------------------------------

\* Original not seen.

**Table 1: The estimates of heterosis over better parent and standard check for different characters in pigeon pea**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Crosses** | **Days to 50% flowering** | | **Days to maturity** | | **Plant height** | |
| **BH (%)** | **SH (%)** | **BH (%)** | **SH (%)** | **BH (%)** | **SH (%)** |
| **1** | **BP-16-184 x UPAS-120** | -6.69\*\* | -2.85\*\* | -0.66 | -1.52 | 6.78\*\* | 11.55\*\* |
| **2** | **BP-16-184 x BP-22-07** | -7.05\*\* | -8.23\*\* | 0.64 | 3.04\*\* | 9.26\*\* | 10.24\*\* |
| **3** | **BP-16-184 x BDN-711** | -15.63\*\* | -9.49\*\* | -2.52\*\* | 0.87 | 11.53\*\* | 9.79\*\* |
| **4** | **BP-16-184 x NP-09-26** | -0.33 | -4.43\*\* | -7.64\*\* | -5.43\*\* | -10.17\*\* | -4.14\*\* |
| **5** | **BP-16-184 x NP-09-30** | -6.65\*\* | -6.65\*\* | -3.86\*\* | -2.61\*\* | 4.56\*\* | 8.03\*\* |
| **6** | **UPAS-120 x BP-22-07** | 3.04\*\* | 7.28\*\* | 1.06 | 3.48\*\* | -3.06\*\* | 1.27 |
| **7** | **UPAS-120 x BDN-711** | -14.16\*\* | -7.91\*\* | -6.09\*\* | -2.83\*\* | -5.84\*\* | -1.64 |
| **8** | **UPAS-120 x NP-09-26** | -0.91 | 3.16\*\* | -3.18\*\* | -0.87 | -7.02\*\* | -0.78 |
| **9** | **UPAS-120 x NP-09-30** | -6.38\*\* | -2.53 | 1.07 | 2.39\*\* | 7.96\*\* | 12.78\*\* |
| **10** | **BP-22-07 x BDN-711** | -9.14\*\* | -2.53 | -0.63 | 2.83\*\* | -2.92\*\* | -2.05\*\* |
| **11** | **BP-22-07 x NP-09-26** | -0.64 | -1.90 | 3.18\*\* | 5.65\*\* | -12.13\*\* | -6.23\*\* |
| **12** | **BP-22-07 x NP-09-30** | -1.90 | -1.90 | -3.18\*\* | -0.87 | -4.28\*\* | -1.11 |
| **13** | **BDN-711 x NP-09-26** | 2.06 | 9.49\*\* | 3.57\*\* | 7.17\*\* | -6.93\*\* | -0.68 |
| **14** | **BDN-711 x NP-09-30** | 4.13\*\* | 11.71\*\* | 1.89\*\* | 5.43\*\* | -5.43\*\* | -2.29\*\* |
| **15** | **NP-09-26 x NP-09-30** | -1.27 | -1.27 | -3.61\*\* | -1.30 | 2.69\*\* | 9.59\*\* |
|  | **S.E. (d) ±** | 2.81 | 2.81 | 4.92 | 4.92 | 7.27 | 7.27 |
|  | **C.D. at 5%** | 5.68 | 5.68 | 9.94 | 9.94 | 14.68 | 14.68 |
|  | **C.D. at 1%** | 7.59 | 7.59 | 13.30 | 13.30 | 19.65 | 19.65 |
|  | **Range** | -15.63 \*\* to  4.13 \*\* | -9.49\*\* to  11.71\*\* | -7.64 \*\* to 3.57\*\* | -5.43 \*\* to 7.17\*\* | -12.13\*\* to  11.53 \*\* | -6.23\*\* to 12.78\*\* |
|  | **No. of crosses in desirable direction** | 07 | 06 | 07 | 03 | 06 | 06 |

**\*, \*\* Significant at 5 per cent and 1 per cent levels of probability, respectively**

**BH = Heterobeltiosis and SH = Standard Heterosis**

**Table 1 Continue…**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Crosses** | **Primary branches per plant** | | **Secondary branches per plant** | | **Pods per plant** | |
| **BH (%)** | **SH (%)** | **BH (%)** | **SH (%)** | **BH (%)** | **SH (%)** |
| **1** | **BP-16-184 x UPAS-120** | -27.46\*\* | -20.82\* | 6.90 | -1.59 | -2.80\*\* | -9.74\*\* |
| **2** | **BP-16-184 x BP-22-07** | 14.77\* | 27.44\* | 9.09 | 14.29\*\* | -0.25 | -15.87\*\* |
| **3** | **BP-16-184 x BDN-711** | -1.16 | 7.26 | 8.93 | -3.17 | 21.48\*\* | 2.46\*\* |
| **4** | **BP-16-184 x NP-09-26** | -29.94\*\* | -26.62\* | 5.36 | -6.35 | -29.41\*\* | -34.38\*\* |
| **5** | **BP-16-184 x NP-09-30** | 25.00\* | 0.95 | 17.86\*\* | 4.76 | 35.92\*\* | 14.63\*\* |
| **6** | **UPAS-120 x BP-22-07** | -14.77\* | -5.36 | 4.55 | 9.52 | -14.07\*\* | -20.20\*\* |
| **7** | **UPAS-120 x BDN-711** | 26.59\*\* | 38.17\*\* | 10.34 | 1.59 | 8.10\*\* | 0.39 |
| **8** | **UPAS-120 x NP-09-26** | -15.03\* | -7.26 | 22.41\*\* | 12.70 | 21.47\*\* | 12.92\*\* |
| **9** | **UPAS-120 x NP-09-30** | 24.28\* | 35.65\*\* | 31.03\*\* | 20.63\*\* | 25.63\*\* | 16.66\*\* |
| **10** | **BP-22-07 x BDN-711** | 7.95 | 19.87\* | -21.21\*\* | -17.46\*\* | 21.71\*\* | -12.85\*\* |
| **11** | **BP-22-07 x NP-09-26** | 5.11 | 16.72\* | -3.03 | 1.59 | -0.71 | -7.69\*\* |
| **12** | **BP-22-07 x NP-09-30** | 13.64\* | 26.18\* | -1.52 | 3.17 | 5.45\*\* | -15.72\*\* |
| **13** | **BDN-711 x NP-09-26** | 21.51\* | 31.86\*\* | 22.22\*\* | 4.76 | 11.86\*\* | 3.98\*\* |
| **14** | **BDN-711 x NP-09-30** | 13.37\* | 23.03\* | 23.21\*\* | 9.52 | -6.63\*\* | -25.37\*\* |
| **15** | **NP-09-26 x NP-09-30** | 25.30\* | 31.23\*\* | 14.64 | 1.90 | 22.56\*\* | 13.93\*\* |
|  | **S.E. (d) ±** | 0.58 | 0.58 | 1.36 | 1.36 | 18.11 | 18.11 |
|  | **C.D. at 5%** | 1.18 | 1.18 | 2.75 | 2.75 | 36.60 | 36.60 |
|  | **C.D. at 1%** | 1.58 | 1.58 | 3.68 | 3.68 | 48.97 | 48.97 |
|  | **Range** | -29.94\*\* to  26.59\*\* | -26.62\* to  38.17\*\* | -21.21 \*\* to  31.03\*\* | -17.46 \*\* to 20.63 \*\* | -29.41 \*\* to  35.92 \*\* | -34.38\*\* to  16.66 \*\* |
|  | **No. of crosses in desirable direction** | 08 | 09 | 05 | 02 | 09 | 06 |

**\*, \*\* Significant at 5 per cent and 1 per cent levels of probability, respectively**

**BH = Heterobeltiosis and SH = Standard Heterosis**

**Table 1 Continue…….**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Crosses** | **Pod length** | | **Seeds per pod** | | **Seed yield per plant** | |
| **BH (%)** | **SH (%)** | **BH (%)** | **SH (%)** | **BH (%)** | **SH (%)** |
| **1** | **BP-16-184 x UPAS-120** | 8.27\* | -0.13 | 4.35 | 21.01\* | -9.55\*\* | -2.93 |
| **2** | **BP-16-184 x BP-22-07** | 23.53\* | 17.05\* | 2.90 | 19.33\* | 0.34 | 7.69\*\* |
| **3** | **BP-16-184 x BDN-711** | 10.97\* | 2.36 | -2.90 | 12.61\* | -0.16 | 7.15\*\* |
| **4** | **BP-16-184 x NP-09-26** | 12.95\* | 4.18 | -20.29\* | -7.56 | 3.41 | 10.99\*\* |
| **5** | **BP-16-184 x NP-09-30** | 12.69\* | 16.66\* | 13.04\* | 31.09\* | 21.68\*\* | 30.60\*\* |
| **6** | **UPAS-120 x BP-22-07** | -9.59\* | -14.33\* | -21.27\* | -12.61\* | -12.62\*\* | -9.53\*\* |
| **7** | **UPAS-120 x BDN-711** | 12.50\* | -16.39\* | -20.97\* | -17.65\* | -14.37\*\* | -13.74\*\* |
| **8** | **UPAS-120 x NP-09-26** | -4.04 | -18.12\* | -23.81\* | -19.33\* | -4.80 | -16.59\*\* |
| **9** | **UPAS-120 x NP-09-30** | 14.10\* | 18.12\* | 20.69\* | 17.65\* | 32.95\*\* | 27.11\*\* |
| **10** | **BP-22-07 x BDN-711** | 12.04\* | 6.17 | 9.01 | 21.01\* | 8.97\*\* | 12.82\*\* |
| **11** | **BP-22-07 x NP-09-26** | 9.24\* | 3.52 | -3.10 | 7.56 | -4.47 | -1.10 |
| **12** | **BP-22-07 x NP-09-30** | 2.56 | 6.17 | -3.10 | 7.56 | 1.01 | 4.58 |
| **13** | **BDN-711 x NP-09-26** | 18.51\* | 1.13 | 21.43\* | 28.57\* | 11.27\*\* | 12.09\*\* |
| **14** | **BDN-711 x NP-09-30** | -2.12 | 1.33 | 0.00 | 4.20 | -6.19\*\* | -5.50\*\* |
| **15** | **NP-09-26 x NP-09-30** | 14.29\* | 18.31\* | 23.41\* | 30.67\* | 29.05\*\* | 23.38\*\* |
|  | **S.E. (d) ±** | 0.18 | 0.18 | 0.22 | 0.22 | 5.68 | 5.68 |
|  | **C.D. at 5%** | 0.36 | 0.36 | 0.44 | 0.44 | 11.47 | 11.47 |
|  | **C.D. at 1%** | 0.49 | 0.49 | 0.59 | 0.59 | 15.35 | 15.35 |
|  | **Range** | -9.59\* to  23.53\* | 18.31 \* to  -18.12\* | -23.81\* to  23.41 \* | -19.33 \* to 31.09 \* | -14.37 \*\* to  32.95 \*\* | -16.59\*\* to  30.60 \*\* |
|  | **No. of crosses in desirable direction** | 11 | 04 | 04 | 08 | 05 | 08 |

**\*, \*\* Significant at 5 per cent and 1 per cent levels of probability, respectively**

**BH = Heterobeltiosis and SH = Standard Heterosis**

**Table 1 Continue…….**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sr. No.** | **Crosses** | **100 seed weight** | | **Protein content** | |
| **BH (%)** | **SH (%)** | **BH (%)** | **SH (%)** |
| **1** | **BP-16-184 x UPAS-120** | -2.23 | 7.79 | -0.63 | -1.23 |
| **2** | **BP-16-184 x BP-22-07** | -18.49\* | -8.13 | 6.55\* | 5.90\* |
| **3** | **BP-16-184 x BDN-711** | 2.23 | 12.72\* | -0.82 | -1.42 |
| **4** | **BP-16-184 x NP-09-26** | 5.57 | 16.40\* | -13.10\*\* | -13.63\*\* |
| **5** | **BP-16-184 x NP-09-30** | 16.37\* | 28.31\* | 2.59 | 1.97 |
| **6** | **UPAS-120 x BP-22-07** | -44.59\*\* | -37.54\*\* | -8.99\* | -9.69\* |
| **7** | **UPAS-120 x BDN-711** | -24.41\* | -24.04\* | 1.94 | 1.15 |
| **8** | **UPAS-120 x NP-09-26** | -25.61\* | -21.62\* | 2.81 | 2.02 |
| **9** | **UPAS-120 x NP-09-30** | 42.93\*\* | 26.07\* | -1.48 | -2.24 |
| **10** | **BP-22-07 x BDN-711** | -7.63 | 4.12 | -8.89\* | -9.94\* |
| **11** | **BP-22-07 x NP-09-26** | -6.52 | 5.37 | 6.21\* | 4.42 |
| **12** | **BP-22-07 x NP-09-30** | 1.11 | 13.97\* | -10.22\* | -13.33\*\* |
| **13** | **BDN-711 x NP-09-26** | 19.09\* | 25.48\* | 8.11\* | 6.86\* |
| **14** | **BDN-711 x NP-09-30** | 4.83 | 5.33 | -13.59\*\* | -14.59\*\* |
| **15** | **NP-09-26 x NP-09-30** | 31.40\*\* | 38.46\*\* | 3.99 | 2.24 |
|  | **S.E. (d) ±** | 0.51 | 0.51 | 0.64 | 0.64 |
|  | **C.D. at 5%** | 1.03 | 1.03 | 1.29 | 1.29 |
|  | **C.D. at 1%** | 1.38 | 1.38 | 1.73 | 1.73 |
|  | **Range** | 42.93 \*\* to  -44.59 \*\* | -37.54\*\* to  38.46\*\* | 8.11 \* to  -13.59 \*\* | 6.86 \* to  -14.59 \*\* |
|  | **No. of crosses in desirable direction** | 04 | 07 | 03 | 02 |

**\*, \*\* Significant at 5 per cent and 1 per cent levels of probability, respectively**

**BH = Heterobeltiosis and SH = Standard Heterosis**