***Original Research Article***

**Exploring Genetic Variability in segregating generations and Biparental progenies for Sustainable Crop Improvement in Bhendi [*Abelmoschus esculentus* (l.) Moench]**

**ABSTRACT**

To assess the degree of genetic variability, heritability, and genetic advance for Economically important traits in bhendi (*Abelmoschus esculentus* (L.) Monech.), three populations such as BIP, F2, and F3 were developed in bhendi during 2022 and analyzed in 2023. On comparing BIP populations to F2 and F3 populations, significant variation was seen for the majority of the characters. This was supported by high means and wider ranges of variation, which were shown by high to moderate PCV and GCV values for fruit length, number of fruits per plant, and fruit yield per plant. The BIPs of Basanthi / Parbhani Kranti recorded high mean performance for traits such asnumber of fruits per plant, fruit length, fruit girth, fruit yield per plant. The superiority of BIPs developed in all the three crosses could be used as base population for developing high yielding early maturing cultivars as they had combined superior performance for earliness and fruit yield per plant. The analysis of components of variance in BIPs in all the three crosses revealed that the additive genetic variance was predominant, which indicated that selection in early intermating generations could result in development of potential progenies.

**Key words:** Bhendi, Genetic variability, Heritability, Genetic Advance and Biparental Progenies.

**INTRODUCTION**

A vital crop in the Malvaceae family is bhendi (*Abelmoschus esculentus* (L.) Monech.), popularly known as okra. Bhendi is particularly regarded for its delicious, tender fruit, which is also a high source of iodine, vitamins and minerals. The more delicate fruits are typically eaten as vegetables. Since this crop is used in every aspect of human life, from food to industry, demand for it is rising significantly. Only genetic modification would be able to satisfy this rising demand, and more advantageous for raising productivity and there is not much land available the manufacturing area. It is essential to use appropriate breeding procedures that include appropriate mating designs to break down unfavorable links in the early segregating generations. Numerous breeding techniques were appropriate for the situation, and one that works well for breaking undesired linkages and producing desirable recombinants is the development of biparental progenies in the early segregating generation. Biparental mating design in accordance with North Carolina Design 1 Model 1 was thus used in the current investigation.

**MATERIALS AND METHODS**

The present investigation was carried out at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Annamalai University from October 2023- July 2024. The experimental material consisted of F2 seeds of three cross combinations and their parents which were obtained from the germplasm collection of Department of Genetics and Plant Breeding, Annamalai University. The three cross combinations are Hisar Unnat / Parbhani (cross 1), Kranti Ankur 40 / Hisar (cross 2), Unnat Basanthi / Parbhani Kranti (cross 3). during October 2017 to January 2018, F2 plants of about 200 plants from each of the three cross combinations were grown on a non-replicated trail with a distance of 45cm between rows and 30 cm between plants. To generate the F3 generation, the F2 population was grown and the seeds were recovered. Besides that, enough F2 seeds were saved to raise the F2 population the next season in order to compare F2, F3, and BIPS progenies. By intermating the randomly chosen F2's as females and males, Biparental progenies (BIPs) were obtained. Were other recommended agronomic measures used, and need-based plant protection measures are followed. Four F2 plants were chosen at random and labelled as males. Each of these males was crossed with four female plants that had been chosen to generate BIPs. No seed parent was used in more than one mating, and the plants used as males and females for the generation of BIPs were selected at random. After being utilized to develop BIPs, the remaining F2 plants were selfed by covering the flower with butter paper cover a day before anthesis. Separate harvests were also made of F3 seeds (selfed F2 plants).

**RESULT AND DISCUSSION**

According to the Analysis of Variance (ANOVA) of BIPs, there were significant variations between the male and female parents for practically every characteristic in every cross that was studied. for the character no of fruits per plant, among the three crosses BIPs of cross 2 showed maximum range (9.00-28.00). The maximum mean value (24.20) was registered in BIPs of cross 3 followed by BIPs of cross 2. Here BIPs of all the crosses recorded high mean values when compared to F2’s and F3’s of corresponding crosses. for the character fruit length, the widest range (9.00-21.00 cm) was recorded in F2’s of cross 1. On comparing the mean values of F2’s, F3’s and BIPs of all the crosses BIPs of cross 2 exhibited maximum mean value (19.25 cm) followed by BIPs of cross 3. For the character fruit yield per plant, maximum range in BIPs of cross 2 (190.00-620.00 g). The maximum mean value for this trait was recorded in BIPs of cross 3 (439.25 g) followed by BIPs of cross 1 (434.00 g). Comparison of mean and range of different characters between biparental (BIPs) and selfed progenies indicated that the mean and range values of BIPs were higher than that of selfed progenies for all the characters studied. The superior means and wider ranges in the biparental progenies may be due to releasing of hidden genetic variability in F2 progenies (Somashekhar guddadamath, 2009). The *per se* performance revealed that the BIPs of cross 3 recorded superior performance for characters *viz.,* number of fruits per plant, fruit length and fruit yield per plant when compared to other crosses. This is followed by BIPs of cross 2, which recorded next best performance for the traits *viz.,* number of fruits per plant, fruit length, fruit girth and fruit yield per plant. In general, BIPs recorded superior mean performance than F3’s for most of the characters studied. This is due to that rare recombinants which remain restricted due to linkage disequilibrium are promptly released by forced recombination and become available for selection in early segregating generations (Koli *et al*. 2018). The range and mean performance of the parents, F2’s, F3’s and BIPs for the traits studied in Bhendi were tabulated in Table 1 to Table 3. The comparison of PCV and GCV in BIPs, F2’s and F3’s population for seven traits showed that estimates of PCV were generally high than GCV for all the characters studied. It denotes that the environmental factors influencing the expression to some degree which is in accordance with findings of Saryam *et al*. (2015) and Jadhav *et al*. (2016). For the trait Number of fruits per plant, Moderate to high PCV and GCV were recorded for this trait in all the crosses studied. Maximum value of PCV was recorded in F2’s of cross 1 (38.32). BIPs of cross 3 (29.42) showed maximum value for GCV. BIPs of all the crosses showed superiority over F3’s for all the crosses. BIPs of cross 2 (79.42) recorded high heritability and BIPs of cross 3 (54.65) recorded maximum genetic advance as per cent of mean for the trait Fruit length, Moderate to high PCV and GCV were recorded in all the crosses studied. Maximum value of PCV was recorded in F2’s of cross 1 (29.30) and maximum value for GCV was recorded in BIPs of cross 3 (28.85). BIPs of cross 3 registered high heritability (89.45) and high genetic advance as per cent of mean (50.78). For the trait Fruit yield per plant, recorded Moderate to high PCV and GCV for all the crosses. Maximum value PCV (23.57) and high GCV (19.85) was recorded in BIPs of cross 3. Maximum value of heritability (90.52) and genetic advance as per cent of mean (33.85) was also recorded in BIPs of cross 3. BIPs of all the crosses recorded high values for genetic advance as per cent of mean when compared to F2’s and F3’s of corresponding crosses. Biparental mating populations showed high PCV and GCV values than F2’s and F3’s for most of the traits *viz.,* days to 50 per cent flowering, plant height, number of fruits per plant, fruit length and fruit yield per plant of cross 3 followed by BIPs of cross 2. The increased genetic variability not available in F3 populations was released in BIP due to intermating of F2 plants. It is also quite interesting to note that the difference between PCV and GCV has been narrowed down in BIPs compared to F3’s, thus indicated that selection could be done directly based on phenotype itself, which is the reflection of the genotype. This narrowed down differences may be due to the accumulation of favorable genes and breaking down of undesirable linkages due to intermating. And it is observed that cross 3 recorded high heritability coupled with high genetic advance as per cent of mean in BIPs for the traits *viz.,* number of fruits per plant, fruit length, fruit girth and fruit yield per plant. In cross 2 traits such as number of fruits per plant and fruit yield per plant recorded high heritability coupled with high genetic advance as per cent of mean. It indicated that in general BIPs recorded moderate to high heritability and genetic advance as per cent of mean for most of the characters, which indicates the additive gene action and simple phenotypic selection may be practiced to improve these characters. Thus, the result obtained was similar to that of result obtained by Deo (2014), Khajuria *et al*. (2015), Kerure *et al*. (2017), Kumar *et al*. (2019), Singh *et al.* (2020), Shwetha *et al*. (2022) and Nanditha et al. (2023). The genetic variability parameters in F2’s, F3’s and BIPs for traits studied in Bhendi were tabulated from Table 4 to Table 6.

**CONCLUSION**

It is observed that, The BIPs of Basanthi / Parbhani Kranti recorded high mean performance for traits such asinternode length, number of fruits per plant, fruit length, fruit girth, fruit yield per plant. The superiority of BIPs developed in all the three crosses counld be used as base population for developing high yielding early maturing cultivars as they had combined superior performance for earliness and fruit yield per plant. The analysis of components of variance in BIPs in all the three crosses revealed that the additive genetic variance was predominant, which indicated that selection in early intermating generations could result in development of potential progenies.

The variability study indicated high PCV and moderate GCV in BIPs of Basanthi / Parbhani Kranti for fruit yield per plant. All the other traits recorded low to moderate PCV and GCV. However, in general BIPs recorded higher values of PCV and GCV when compared to F3’s for almost all the characters studied. This variability in BIPs might be attributed due to breakage of linkage group obtained through intermating of early segregating generations. High heritability coupled with high genetic advance as per cent of mean was observed in BIPs of Basanthi / Parbhani Kranti for the traits *viz.,* number of fruits per plant, fruit length, fruit yield per plant which revealed the importance of additive gene action for these traits. Presence of low to moderate PCV and GCV coupled with high heritability and genetic advance as per cent of mean for these traits indicated the presence of both additive and non-additive gene action (dominance and epistasis).

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**Table 1. Range and mean performance of parents, F2’s, F3’s and BIPs for number of fruits per plant in Bhendi**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parents / Generation** | | **Cross 1** | **Cross 2** | **Cross 3** | **General mean** |
| P1 | Range | 15.00-25.00 | 14.00-20.00 | 15.00-24.00 | 14.96 |
| Mean | 15.60 | 13.20 | 16.10 |
| P2 | Range | 14.00-22.00 | 15.00-20.00 | 13.00-18.00 | 18.43 |
| Mean | 21.00\*\* | 15.10 | 19.20\* |
| F2 | Range | 12.00-20.00 | 11.00-25.00 | 6.00-22.00 | 20.55 |
| Mean | 18.25\* | 23.30\*\* | 20.10\* |
| F3 | Range | 12.00-31.00 | 6.00-23.00 | 15.00-26.00 | 21.36 |
| Mean | 21.50\*\* | 20.10\*\* | 22.50\*\* |
| BIPs | Range | 8.00-26.00 | 9.00-28.00 | 12.00-29.00 | 23.58 |
| Mean | 23.05\*\* | 23.50\*\* | 24.20\*\* |

**Table 2. Range and mean performance of parents, F2’s, F3’s and BIPs for fruit length (cm) in Bhendi**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parents / Generation** | | **Cross 1** | **Cross 2** | **Cross 3** | **General mean** |
| P1 | Range | 12.00-14.00 | 13.00-16.00 | 9.00-12.00 | 11.90 |
| Mean | 13.00 | 13.50 | 9.20 |
| P2 | Range | 9.50-15.00 | 8.00-14.00 | 9.40-14.00 | 12.30 |
| Mean | 13.50\* | 9.60 | 13.80 |
| F2 | Range | 9.00-21.00 | 11.00-17.00 | 8.00-18.00 | 14.57 |
| Mean | 15.60\*\* | 12.40 | 15.70\* |
| F3 | Range | 7.00-17.00 | 8.60-18.00 | 8.00-19.00 | 16.20 |
| Mean | 14.90 | 15.80\*\* | 17.90\*\* |
| BIPs | Range | 18.00-26.00 | 16.00-27.00 | 16.00-22.00 | 17.72 |
| Mean | 15.90\*\* | 19.25\*\* | 18.00\*\* |

**Table 3. Range and mean performance of parents, F2’s, F3’s and BIPs for fruit yield per plant (g) in Bhendi**.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parents / Generation** | | **Cross 1** | **Cross 2** | **Cross 3** | **General mean** |
| P1 | Range | 200.00-290.00 | 295.00-450.00 | 250.00-306.00 | 299.53 |
| Mean | 230.00 | 392.90 | 275.70 |
| P2 | Range | 220.00-300.00 | 200.00-340.00 | 220.00-350.00 | 261.67 |
| Mean | 260.00 | 245.00 | 280.00 |
| F2 | Range | 420.00-570.00 | 430.00-670.00 | 370.00-560.00 | 430.43 |
| Mean | 430.00\*\* | 440.70\*\* | 420.60 |
| F3 | Range | 230.00-560.00 | 200.00-567.00 | 320.00-560.00 | 418.82 |
| Mean | 410.60 | 412.06 | 433.80\*\* |
| BIPs | Range | 300.00-600.00 | 190.00-620.00 | 220.80-640.00 | 431.20 |
| Mean | 434.00\*\* | 420.35\*\* | 439.25\*\* |

\*Significant at 5 per cent level \*\*Significant at 1 per cent level

**Table 4. Genetic variability parameters in F2’s, F3’s and BIPs for number of fruits per plant in Bhendi.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Crosses** | **Population** | **PCV**  **(per cent)** | **GCV**  **(per cent)** | **Heritability (per cent)** | **Genetic Advance** | **Genetic Advance as per cent of mean** |
| Cross 1 | F2 | 38.32 | 27.23 | 67.91 | 7.04 | 50.72 |
| F3 | 31.24 | 27.14 | 68.52 | 6.96 | 45.73 |
| BIPs | 28.93 | 27.91 | 79.31 | 6.59 | 46.31 |
| Cross 2 | F2 | 34.56 | 27.85 | 64.82 | 5.78 | 44.74 |
| F3 | 26.74 | 20.31 | 66.72 | 5.67 | 35.62 |
| BIPs | 31.53 | 23.53 | 79.42 | 6.93 | 50.61 |
| Cross 3 | F2 | 32.64 | 26.74 | 53.81 | 5.42 | 35.82 |
| F3 | 28.54 | 18.54 | 46.81 | 3.65 | 25.76 |
| BIPs | 32.67 | 29.42 | 79.23 | 7.20 | 54.65 |

**Table 5. Genetic variability parameters in F2’s, F3’s and BIPs for fruit length in Bhendi**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Crosses** | **Population** | **PCV**  **(per cent)** | **GCV**  **(per cent)** | **Heritability (per cent)** | **Genetic Advance** | **Genetic Advance as per cent of mean** |
| Cross 1 | F2 | 29.30 | 24.97 | 71.57 | 5.79 | 41.56 |
| F3 | 16.40 | 8.90 | 23.53 | 0.98 | 8.69 |
| BIPs | 28.32 | 26.75 | 84.26 | 7.32 | 48.89 |
| Cross 2 | F2 | 15.63 | 1.02 | 0.53 | 0.09 | 0.09 |
| F3 | 28.90 | 26.32 | 81.54 | 7.23 | 42.00 |
| BIPs | 11.94 | 4.21 | 14.52 | 0.64 | 2.90 |
| Cross 3 | F2 | 15.63 | 5.20 | 11.41 | 0.78 | 3.53 |
| F3 | 15.69 | 11.49 | 50.63 | 1.95 | 16.89 |
| BIPs | 29.10 | 28.85 | 89.45 | 8.17 | 50.78 |

**Table 6. Genetic variability parameters in F2’s, F3’s and BIPs for fruit yield per plant in Bhendi.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Crosses** | **Population** | **PCV**  **(per cent)** | **GCV**  **(per cent)** | **Heritability (per cent)** | **Genetic Advance** | **Genetic Advance as per cent of mean** |
| Cross 1 | F2 | 22.34 | 16.78 | 67.85 | 129.94 | 31.56 |
| F3 | 20.45 | 16.74 | 57.45 | 96.74 | 24.71 |
| BIPs | 22.62 | 17.94 | 78.93 | 134.65 | 31.68 |
| Cross 2 | F2 | 19.98 | 15.56 | 58.52 | 99.56 | 23.54 |
| F3 | 18.87 | 15.79 | 68.87 | 129.86 | 30.75 |
| BIPs | 22.19 | 18.32 | 81.28 | 115.84 | 31.76 |
| Cross 3 | F2 | 17.45 | 16.76 | 73.59 | 132.75 | 28.73 |
| F3 | 16.53 | 13.54 | 72.49 | 97.56 | 23.75 |
| BIPs | 23.57 | 19.85 | 90.52 | 149.96 | 33.85 |

**PCV and GCV Heritability Genetic Advance as per cent of mean**

Below 10 per cent – low Below 30 per cent – Low Below 10 per cent – low

10-20 per cent – moderate 30 – 60 per cent – Moderate 10 – 20 per cent – moderate

Above 20 per cent – High Above 60 per cent – High Above 20 per cent - High