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Estimation of generation mean analysis and scaling test for fruit yield and its attributing traits in Okra *Abelmoschus esculentus* (L) Moench

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Abstract

The experimental material comprised of six generations (P₁, P₂, F₁, F₂, BC₁ and BC₂) derived from five crosses (Parbhani Kranti x Shagun, Arka Anamika x PBN-1, Shagun x AKO-107, Akola bahar x PBN-13, AKO-107 x Pusa sawani) between different parents (Parbhani Kranti, Arka Anamika, Shagun, Akola Bahar, AKO-107, PBN-1, PBN-13, Pusa Sawani) along with check Ankur-40 (Hybrid). The material was evaluated during *kharif* 2013 in a randomized block design with randomization of generation replicated twice. The characters studied were plant height (cm), internodal length (cm), number of branches per plant, days to 50% flowering, fruit length (cm), fruit weight (g), fruit diameter (cm), number of fruit per plant, fruit yield per plant (g), fruit yield per ha. (q). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. The crosses Parbhani kranti x Shagun and Akola Bahar x PBN-13 showed superior mean performance for fruit yield per plant. However the cross Parbhani kranti x Shagun depicted superior performance for maximum number of characters studies. Superior hybrid was developed from the combination of parents Shagun and Ako-107 and for economically important traits like fruit yield per plant compared with P₁, P₂, F₁, F₂, BC₁ and BC₂ parameter in its generation system. However, the cross Arka Anamika x PBN-1 showed superior performance compared with remaining four crosses. In most of the crosses, additive x additive type of gene action played an important role in the inheritance of days to 50 % flowering. Dominance type gene action was observed to be important in the inheritance of characters like yield per plant, plant height, fruit length and fruit diameter. Dominance type of gene action would favour for production of hybrids. Most of the characters under study showed duplicate type of gene action, as such, transgressive variation can be obtained in the characters. Complimentary type of gene action was observed to play an important role in the inheritance fruit diameter to greater extent.

Keywords: Okra, Generation mean analysis, yield components, P₁, P₂, F₁, F₂, BC₁ and BC₂

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the popular vegetables commonly known as lady's finger in India, is native of tropical Africa. It is the choicest fruit vegetable grown extensively in the tropical, subtropical and warm area of the world. Crop improvement in Okra needs to focus on plant height, higher yield, early flowering, number of branching, fruit length, diameter of fruit, intermodal length, number of fruits per plant, disease pest resistance and high yield. Moreover, exploitation of hybrid vigor, understanding the genetics of various characters and the improvement of quality aspects with an eye on the export market need to be concentrated upon in okra improvement programs. Exploitation of hybrid vigor in Okra has been recognized as a practical tool in providing the breeders a means of increasing the yield. Photo insensitive nature and shorter growth period enables the plant breeder to grow 2-3 Okra crops in a year, thus genetic studies can be conducted in a short time. Also, relative ease of hybridization in Okra due to its monadelphous nature, higher degree of fruit set and fairly large number of seeds per fruit points to a good scope for commercial hybrid seed production.

Materials and Methods

The experimental material comprised of six generations (P₁, P₂, F₁, F₂, BC₁ and BC₂) derived from five crosses. The parents were crossed to produce five single cross hybrids (Parbhani Kranti x Shagun, Arka Anamika x PBN-1, Shagun x AKO-107, Akola bahar x PBN-13, AKO-107 x Pusa sawani) between different parents (Parbhani Kranti, Arka Anamika, Shagun, Akola Bahar, AKO-107, PBN-1, PBN-13, Pusa Sawani) along with check Ankur-40 (Hybrid). The material was evaluated during *kharif* 2013 in a randomized block design with randomization of generation replicated twice.

The characters studied were plant height (cm), internodal length (cm), number of branches per plant, days to 50% flowering, fruit length (cm), fruit weight (g), fruit diameter (cm), number of fruit per plant, fruit yield per plant (g), fruit yield per ha. (q). The experimental plot size 6.3m x 3.6m and net plot size were 5.7m x 3m, spaced at 30cm x 30cm between and within rows in separate RBD for each cross. The plot were dibbled and thinned to 20 plants per row. Each plot consisted spacing of 30 cm between rows and 30 cm within row. Experiment were carried out at the Experimental Farm, Department of Agricultural Botany, College of Agriculture, Latur

Results and Discussion

The analysis of variance for randomized block design was carried out for plant height, internodal length, days to 50 per cent flowering, number of branches per plant, number of fruit per plant, diameter of fruit, length of fruit, weight of fruit, green fruit yield per plant, fruit yield per hectare. Analysis of variance showed highly significant differences and were present among the crosses studied for all the characters. This indicated the existence of sufficient variation for effective selection for all the characters in the material studied. (Table-1)

The mean value for Plant height in five crosses recorded from ranged 135.00cm (Parbhani kranti) to 138.16cm (AKO-107), while, in the crosses it ranged from 138.00cm (Parbhani Kranti x Shagun) to 142.00cm (Arka Anamika x PBN-1). Mean values of F₂ generations of all the five crosses ranged from 135.75cm (AKO-107 x Pusa Sawani) to 137.60 cm (Arka Anamika x PBN-1). The back cross generation ranged in between F₁ and their respective parents except in crosses B₁ of (Parbhani Kranti x Shagun) and (Akola Bahar x PBN-13). and in B₂ of (AKO-107 x Pusa Sawani). Variability result for this trait were reported by Swamy Rao and Ramu (1975)^[5], Bello *et al.* (2006) and Ramanjinappa *et al.* (2011). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. (Table-3) Inheritance study for plant height revealed that additive gene action played important role in the cross AKO-107 x Pusa Sawani for the expression of this trait. The dominance component was positively significant in three crosses Parbhani Kranti x Shagun, Arka Anamika x PBN-1 and Shagun x AKO-107. Among epistasis, additive x additive gene effect had major contribution than dominance x dominance. Epistatic effects were predominant in the cross Akola Bahar x PBN-13. Dominance x dominance epistatic effects were predominant in the cross Shagun x AKO-107. Prevalence of dominance genetic effects is more helpful in the formation of superior Okra hybrids. Absolute epistatic total ranged from 6.79 to 42.67, whereas, after internal cancellation. It was reduced up to -10.74 to 10.61 (Table 11). Generally contributions of epistatic gene effects were greater than main effects. The presence of epistasis is mostly indicative of greater genetic diversity in the parents. The significant values for genetic components, dominance (h) and dominance x dominance (i), with opposite signs were indicative of duplicate type of epistasis in the inheritance of this trait in all the crosses. Varying role of gene actions for controlling this trait have been reported by Chandrashekar *et al.* (1998) while additive gene action Predominant for plant height was reported by Thaker *et al.* (1981), Bello *et al.* (2006), Singh J.N. (2010)^[1-4]. The mean value for internodal length recorded from ranged 9.4cm (Parbhani kranti) to 7.90cm (Pusa Sawani). In F₁ crosses, internodal length on stem were maximum in Parbhani

Kranti x Shagun (9.10cm) and it ranged from 8.10cm (AKO-107 x Pusa Sawani) to 9.10cm (Parbhani Kranti x Shagun). In F₂ cross Parbhani Kranti x Shagun (8.90cm) showed highest internodal length on stem while the cross AKO-107 x Pusa Sawani (8.00cm) Showed lowest internodal length, while in the back crosses mean values ranged in between F₁ and other parental values except in BC₁ of Shagun x AKO-107. Variability result for this trait were reported by Jindal *et al.* (2010) and Ramanjinappa *et al.* (2011). Investigation for inheritance of internodal length stem showed additive (d) positive and significant in the four crosses Parbhani Kranti x Shagun, Arka Anamika x PBN-1, Akola Bahar x PBN-13, AKO-107 x Pusa Sawani. Similarly dominance effect was found negative and significant in four crosses. Among the epistasis, additive x additive gene effect was significant in the crosses Arka Anamika x PBN-1, Shagun x AKO-107 and Akola Bahar x PBN-13 indicates scope for selection of plants, whereas additive x dominance interaction was significant in all five crosses. Absolute epistatic total ranged from 0.65 to 5.25 whereas after internal cancellation it was reduced up to 0.65 to 2.15. And Dominance x dominance interaction was also significant in all five crosses indicating hybrid development is suitable in okra. Internodal length trait have been reported by Lal *et al.* (1977) and Jindal *et al.* (2010). Duplicate type of interaction was observed to be present in all five crosses as (h) and (L) components have different signs.

The mean value for number of branches per plant exhibited significant differences. Maximum number of branches per plant was produced by the parent AKO-107 (4.62) and PBN-1 (3.50) exhibited least number of branches per plant. In the F₁ crosses Parbhani Kranti x Shagun and Akola Bahar x PBN-13 highest number of branches (5.00) where as Arka Anamika x PBN-1 (4.37) displayed least number of branches. In B₁ cross Akola Bahar x PBN-13 showed higher number of branches (5.10) and (5.00) respectively. Variability result for this trait were reported by Panda P.K. and Singh K.P. (2005), Bello *et al.* (2006), Jindal *et al.* (2010). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. Among the epistasis, additive x additive interaction was significant in four crosses Parbhani Kranti x Shagun, Shagun x AKO-107, Akola Bahar x PBN-13 and AKO-107 x Pusa Sawani, indicates scope for selection, where as additive x dominance interaction were significant in three crosses Arka Anamika x PBN-1, Shagun x AKO-107 and AKO-107 x Pusa Sawani this indicates to scope for selection. Dominance x dominance interaction was significant in four crosses these crosses can be used for hybrid development programme. Absolute epistatic total ranged from 2.09 to 8.55 whereas after internal cancellation it was reduced up to -1.69 to -0.24. Singh (2005) also suggested similar views in his inheritance study of okra. The character number of branches per plant important for yield. On the basis of generation mean analysis was predominantly under the control of additive (d) and dominance effects in all five crosses. Similar results were observed by Bello *et al.* (2006), and Jindal *et al.* (2010), Singh J.N. (2010)^[1-4]. Duplicate type of interaction was observed to be present in all five crosses as (h) and (L) components have different signs. The mean value for days to 50 per cent flowering, AKO-107 were found to be earliest (43.75 days) and Akola Bahar were found to be late (45.66) among the parents. The mean value of days to 50 per cent flowering of F₁ population were in the range of their respective parents for all crosses. Among five F₂ population three crosses were found to be late and two crosses were found to be same days (43.00 days). In B₁ population cross

Arka Anamika x PBN-1 found late (45.56days) and cross AKO-107 x Pusa Sawani earliest (42.28) and in B₂ population cross Akola Bahar x PBN-13 found earliest (42.20days) and cross Parbhani Kranti x Shagun found late (44.25days). Variability result for this trait were reported by Swamy Rao and Ramu (1975)^[5] and Bello *et al.* (2006). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. The character, days to 50% flowering is important for earliness. On the basis of generation mean analysis, the crosses Shagun x AKO-107 and Akola Bahar x PBN-13 which was positive and significant interaction, whereas, three crosses negative and significant for additive component. The negative value for days to 50 per cent flowering in the crosses Shagun x AKO-107 and Akola Bahar x PBN-13 indicating the predominance of dominance gene action in their inheritance, Additive x additive component was observed to be positively significant in crosses Parbhani Kranti x Shagun and Arka Anamika x PBN-1, negatively significant in crosses, Shagun x AKO-107, Akola Bahar x PBN-13 and AKO-107 x Pusa Sawani. Additive x dominance interaction was observed to be significant and positive in three crosses and cross the Shagun x AKO-107 observed to be negatively significant and cross AKO-107 x Pusa Sawani which was observed to be non significant. Dominance x dominance interaction was observed to be significant and negative in the tow crosses Parbhani Kranti x Shagun and Arka Anamika x PBN-1, it was Positively significant in three crosses *viz.* Shagun x AKO-107, Akola Bahar x PBN-13 and AKO-107 x Pusa Sawani. Similar results were reported by Swami Rao and Ramu (1975)^[5], Singh and Singh (1978) and Adenji and Olawale Taino (2007).

Absolute epistatic total ranged from 7.57 to 48.02 whereas after internal cancellation it was reduced up to 1.00 to 3.42. This indicating scope for development of hybrids for such combinations. Duplicate type of interaction was observed to be present in all five crosses as (h) and (L) components have different signs Estimates of mean performance for fruit length in five crosses. Among the parent the range of fruit length was from 11.25cm (Shagun) to 13.40 cm (Akola Bahar and Pusa Sawani). In crosses, fruit length were maximum in Shagun x AKO-107 (13.50cm). In F₂ population cross Shagun x AKO-107 showed highest fruit length (12.80cm) while in cross Parbhani Kranti x Shagun showed lowest fruit length (11.70cm). In back crosses mean values were ranged in between F₁ and their parent values except in B₁ of AKO-107 x Pusa Sawani showed variation for fruit length. In B₂ cross Shagun x AKO-107 (13.50cm) showed highest fruit length. Variability result for this trait were reported by Nichal *et al.* (2006), Deepak Arora *et al.* (2008) and Jindal *et al.* (2010). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. Investigation for inheritance of fruit length showed that additive and dominance effects played major role in the crosses Akola Bahar x PBN-13, Parbhani Kranti x Shagun. Dominance effect was higher than additive in the all five crosses. The gene effects, additive x additive component was significant in the crosses Akola Bahar x PBN-13, and Arka Anamika x PBN-1 indicates scope for selection. Dominance x dominance component was observed significant in three crosses *viz.* Parbhani Kranti x Shagun, Arka Anamika x PBN-1, Shagun x AKO-107, Akola Bahar x PBN-13 and AKO-107 x Pusa Sawani. This indicates there is a much scope for development of hybrid. Additive x dominance interaction was significant in the all crosses but only one cross (Arka Anamika x PBN-1) was positively significant indicates less chance of selection. Absolute

epistatic total ranged from 0.82 to 5.50 where as after internal cancellation it was reduced up to -0.42 to 2.20. Similar results were reported by Nichal *et al.* (2006) and Jindal *et al.* (2010). Duplicate type of interaction is present in all crosses as (h) and (L) component have same Mean value for parental for fruit weight, lines PBN-1 had highest fruit weight (17.95g). The fruit weight in F₁ ranged in between 16.35g (AKO-107 x Pusa Sawani) to 17.65g (Arka Anamika x PBN-1). Mean performance of F₁ in the cross Akola Bahar x PBN-13 was superior than the respective parents, while the F₂ shows decrease in fruit weight. Generally in all the five crosses BC₁ and BC₂ mean values were within the range of their respective parents and F₁ mean value except in BC₂ of Parbhani Kranti x Shagun, Shagun x AKO-107 recorded lower F₁ mean value for the trait. Variability result for this trait were reported by Nichal *et al.* (2006) and Jindal *et al.* (2010). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. Investigation for inheritance of fruit weight showed that additive and dominance component played important role in the crosses Parbhani Kranti x Shagun, Arka Anamika x PBN-1 and Akola Bahar x PBN-13, these both gene effects indicate for population development for recurrent selection breeding in these crosses. Dominance effect was higher than additive effects. Additive x additive interaction were significant and positive in all five crosses, except the cross AKO-107 x Pusa Sawani which was observed to be non-significant. Additive x dominance interaction was significant and positive in two crosses, Shagun x AKO-107, AKO-107 x Pusa Sawani. Dominance x dominance interaction was negatively significant interaction in two crosses Arka Anamika x PBN-1, Akola Bahar x PBN-13 other three crosses were non-significant. These results were in agreement with Das A. K. *et al.* (1996)^[2] and Aher R. P. (2003). Absolute contribution of epistatic gene effects ranged from 6.79 to 42.67 whereas after internal cancellation it reduced to -2.54 to 10.61. The contribution of epistatic gene effects were greater than main effects. In the five crosses four cross were genetic components (h) and (l) were having opposite sign indicated duplicated type of gene action. However the cross Shagun x AKO-107 genetic components (h) and (l) were having same sign this indicating complimentary type of gene action.

The mean value of parent showed that Parbhani Kranti was with highest diameter of fruit (1.91cm) and lowest was PBN-1 (1.72cm). In the F₁ crosses, mean value was ranged from 1.80cm (Shagun x AKO-107) to 1.95cm (Parbhani Kranti x Shagun). In the F₂ crosses lowest value was (1.73cm) in Arka Anamika x PBN-1 and highest was (1.85cm) in Parbhani Kranti x Shagun. The mean of back crosses BC₁ lowest value was in cross Shagun x AKO-107 (1.66cm) and highest in cross Arka Anamika x PBN-1 (1.97cm). In BC₂ of Arka Anamika x PBN-1 (1.90cm) showed higher mean value than their respective F₁'s and recurrent parents. Variability result for this trait were reported by Bello *et al.* (2006), Deepak Arora *et al.* (2008) and Jindal *et al.* (2010). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. Investigation for the inheritance of diameter of fruit showed that additive component was positive and significant in three crosses *viz.* Parbhani Kranti x Shagun, Arka Anamika x PBN-1 and Akola Bahar x PBN-13 and the cross Shagun x AKO-107 observe to be non-significant. Dominance component was positive and significant in all crosses, except the cross Shagun x AKO-107 which showed negatively significant interaction and cross AKO-107 x Pusa Sawani which was observed to be non-significant interaction. The additive component couple with additive x additive indicates

selection in segregating generation could improve this character. Additive x additive interaction was positive and significant in all the crosses except the cross Shagun x AKO-107 which was negative and significant. Additive x dominance interaction was negatively significant in two cross Parbhani Kranti x Shagun and AKO-107 x Pusa Sawani and two crosses were positive and non-significant cross Parbhani Kranti x Shagun and Shagun x AKO-107. Dominance x dominance interaction was positively significant in the cross Shagun x AKO-107. In the crosses Parbhani Kranti x Shagun and AKO-107 x Pusa Sawani cross which was observed to be non-significant interaction. Absolute total ranged from 0.12 to 2.06 whereas it reduced upto -0.03 to 0.46 after internal cancellation. Similar results were obtained by Jindal *et al.* (2010).

Duplicate type of gene effect was present in four crosses. In cross AKO-107 x Pusa Sawani genetic components (h) and (l) were having same sign there by indicating Complimentary type of gene effect. The mean value for character number of fruit per plant, Arka Anamika (13.12) had highest number of fruits per plant. The number of fruit per plant in the crosses ranged between 13.50 (Akola Bahar x PBN-13) to 14.12 (Arka Anamika x PBN-1). Mean performance of F₁ in the cross Parbhani Kranti x Shagun (14.00) was superior than the respective parents. Generally in all the five crosses of back crosses BC₁ mean values were within the range (13.00 to 14.00) of their respective parent and BC₂ mean value highest in cross Akola Bahar x PBN-13 (13.75) and lowest in cross Arka Anamika x PBN-1 (12.35). Variability result for this trait were reported by Bello *et al.* (2006), Nichal *et al.* (2006), Jindal *et al.* (2010) and Ramanjinappa *et al.* (2011). The scaling test indicated the presence of non-allelic gene interaction in all the crosses. Investigation for inheritance of number of fruit per plant showed that, additive components were significant except two crosses were negatively significant in cross Parbhani Kranti x Shagun and Akola Bahar x PBN-13. While dominance component was significant and negative in only one cross Arka Anamika x PBN-1 and in other four crosses it was positive and significant interaction. Additive x additive interaction was significant and positive in the crosses Parbhani Kranti x Shagun, Shagun x AKO-107, Akola Bahar x PBN-13, AKO-107 x Pusa Sawani. While it was significant and negative in cross Arka Anamika x PBN-1. Additive x dominance interaction was positive and significant in three crosses but in cross Akola Bahar x PBN-13 it was negatively significant and cross AKO-107 x Pusa Sawani showed positively non-significant interaction. Dominance x dominance interaction was negative and significant in all crosses except cross Arka Anamika x PBN-1 which showed positive and significant interaction and cross AKO-107 x Pusa Sawani which was observed to be non-significant interaction. The additive gene effect (d) predominated for number of fruit per plant in cross Arka Anamika x PBN-1 suggesting scope for selection. Absolute contribution of epistatic gene effects ranged from 2.51 to 12.09 whereas after internal cancellation it reduced to -1.51 to 2.79, gene effects were greater than main effects. These result were in agreement with Deepak Arora *et al.* (2008), Abdul Naveed *et al.* (2009) Akhtar *et al.* (2010) [1] and Singh J.N. (2010) [1-4]. Duplicate type of interaction is present in all crosses as (h) and (L) component have same signs. The mean values for green fruit yield per plant among parents was varied from 198.76g (Shgun) to 219.87g (PBN-

1). While in the crosses it was ranged from 224.19g (AKO-107 x Pusa Sawani) to 249.21g (Arka Anamika x PBN-1). Mean value of F₂ generations of all five crosses ranged from 207.21g (Akola Bahar x PBN-13) to 227.51g (Arka Anamika x PBN-1). The back cross generation BC₁ ranged between 221.00g AKO-107 x Pusa Sawani to 235.16g (Parbhani Kranti x Shagun). The value of BC₂ ranged in between F₁ and their respective recurrent parent. Variability result for this trait were reported by Bello *et al.* (2006), Nichal *et al.* (2006), Jindal *et al.* (2010) and Gangashetty *et al.* (2010) Yadav *et al.* (2010) [7]. The scaling test indicated the presence of non-allelic gene interaction in all the crosses. Inheritance of green fruit yield per plant was governed by both additive and non additive gene effects in all five crosses. Additive and dominance both the components play important role in the cross Parbhani Kranti x Shagun, indicating the chance for population development for recurrent selection breeding. Among the epistatis, additive x dominance gene effects were important in all the five crosses. Additive x additive gene effects were important in four crosses Parbhani Kranti x Shagun, Shagun x AKO-107, Akola Bahar x PBN-13 and AKO-107 x Pusa Sawani, and Dominance x dominance gene effects the cross Arka Anamika x PBN-1 which indicates the chance for selection of plants in these crosses. These result were in agreement with Abdul Naveed *et al.* (2009) and Singh J.N. (2010) [1-4]. Absolute contribution of epistatic gene effects ranged from 54.01 to 225.87 whereas after internal cancellation it reduced to -44.93 to 56.82. Generally contributions of epistasis gene effects were greater than main effects. In the crosses component (h) and (l) were having opposite signs thus showing duplicate type of interaction. Estimates of generation mean for green fruit yield per ha in five crosses the range of green fruit yield per hectare from 220.84q (Shagun) to 244.30q (PBN-1). In crosses F₁ the range of green fruit yield per hectare was from 249.89q (AKO-107 x Pusa Sawani) to 276.89q (Arka Anamika x PBN-1). In F₂ cross, (Arka Anamika x PBN-1) showed highest green fruit yield per ha. (253.13 q). In the back cross generation BC₁ value ranges from 245.15q (Arka Anamika x PBN-1) to 261.23 q (Parbhanikranti x shagun) In BC₂ mean values were ranged in between F₁'s and their recurrent parent. Variability result for this trait were reported by Bello *et al.* (2006), Jindal *et al.* (2010) and Yadav *et al.* (2010) [7]. The scaling test indicated the presence of non-allelic gene interaction in all the crosses. In present investigation green fruit yield per ha appeared to be controlled mainly by both additive and non-additive type of gene action in crosses Parbhani Kranti x Shagun, Arka Anamika x PBN-1, Shagun x AKO-107, Akola Bahar x PBN-13 and AKO-107 x Pusa Sawani. Inheritance study revealed that additive as well as dominance gene effects were important in crosses Akola Bahar x PBN-13, Parbhani Kranti x Shagun indicates there is scope for selection, exploitation of hybrid vigour and selection of plants for recurrent selection. Absolute totals of epistatic effects ranged from 59.97 to 251.01, whereas it reduced after internal cancellation epistatis gene effect ranged between -49.93 to 63.16. Epistatic effects after internal cancellation were less than dominance and additive effects in crosses. Parbhani Kranti x Shagun and Akola Bahar x PBN-13. Similar results were reported by Akhtar *et al.* (2010) [1], Singh J.N. (2010) [1-4] and Yadav *et al.* (2010) [7]. In the crosses component (h) and (l) were having opposite signs thus showing duplicate type of interaction.

Table 1: Analysis of variance (Mean sum of squares) of generation means for 10 characters in 5 crosses in okra

Source of variance	d.f.	Plant height (cm)	Internodal length (cm)	Number of branches per plant	Days to 50 % flowering	Fruit length (cm)	Fruit weight (g)	Diameter of fruit (cm)	Number of fruit per plant	Fruit yield per plant (g)	Fruit yield per ha (q)
Parbhani kranti x Shagun											
Replication	1	0.23	0.001	0.02	0.003	0.001	0.13	0.001	0.01	0.37	0.09
Treatment	6	6.10**	0.15*	0.25*	0.96*	0.23*	1.35*	0.009*	1.01*	543.05**	692.86**
Error	6	0.58	0.02	0.03	0.17	0.03	0.29	0.001	0.21	40.42	42.90
Arka Anamika x PBN-1											
Replication	1	0.02	0.002	0.06	0.002	0.01	0.20	0.001	0.06	13.68	10.01
Treatment	6	10.38**	0.15*	0.43*	1.34*	0.17*	1.84*	0.016*	1.05**	376.86**	466.40*
Error	6	0.83	0.03	0.08	0.20	0.03	0.36	0.003	0.09	36.02	67.32
Shagun x AKO-107											
Replication	1	0.50	0.006	0.07	0.05	0.01	0.10	0.001	0.02	1.36	36.06
Treatment	6	3.87*	0.11*	0.40*	1.27*	1.33**	0.86*	0.007*	0.75**	380.25**	469.47*
Error	6	0.54	0.01	0.06	0.25	0.09	0.13	0.001	0.06	36.95	57.21
Akola Bahar x PBN-13											
Replication	1	0.25	0.006	0.001	0.04	0.03	0.07	0.001	0.01	2.83	7.60
Treatment	6	2.12*	0.16*	0.15*	3.83*	0.45**	1.07**	0.02*	0.83**	423.58**	522.97**
Error	6	0.49	0.02	0.03	0.73	0.02	0.09	0.003	0.05	30.22	35.25
AKO-107 x Pusa Sawani											
Replication	1	0.06	0.001	0.001	0.01	0.001	0.08	0.001	0.04	0.10	0.28
Treatment	6	6.20**	0.39*	0.58**	0.73*	0.58**	0.96*	0.01**	0.65*	93.72**	115.69*
Error	6	0.51	0.06	0.06	0.10	0.05	0.14	0.001	0.09	8.25	16.88

*, **significance at 5% and 1 % respectively

Table 2: Mean performance of six generation in 5 crosses for 10 characters in okra.

Character and Cross	P ₁	P ₂	F ₁	F ₂	B ₁	B ₂
Plant Height (cm)						
Parbhani kranti x Shagun	135.00±0.08	136.00±0.06	138.00±0.16	136.00±0.10	138.24±0.05	140.00±0.16
Arka Anamika x PBN-1	137.00±0.11	138.00±0.18	142.00±0.13	137.60±0.06	141.50±0.11	142.21±0.20
Shagun x AKO-107	136.00±0.10	138.16±0.11	140.10±0.10	137.50±0.05	139.25±0.26	139.57±0.10
Akola Bahar x PBN-13	136.20±0.03	137.50±0.25	138.50±0.20	136.65±0.11	137.46±0.14	134.78±0.04
AKO-107 x Pusa Sawani	138.66±0.11	136.66±0.05	140.00±0.08	135.75±0.05	135.20±0.03	136.17±0.06
Internodal length (cm)						
Parbhani kranti x Shagun	9.10±0.03	8.60±0.03	9.10±0.03	8.90±0.02	9.20±0.02	8.60±0.02
Arka Anamika x PBN-1	8.70±0.03	8.50±0.06	8.20±0.03	8.10±0.03	8.20±0.02	7.90±0.02
Shagun x AKO-107	8.60±0.03	8.80±0.03	8.40±0.00	8.20±0.02	8.10±0.02	8.40±0.02
Akola Bahar x PBN-13	9.00±0.03	8.30±0.03	8.60±0.03	8.30±0.02	8.40±0.02	8.10±0.02
AKO-107 x Pusa Sawani	8.80±0.03	7.90±0.06	8.10±0.06	8.00±0.04	7.80±0.04	7.50±0.02
Number of branches per plant						
Parbhani kranti x Shagun	4.50±0.08	4.00±0.03	5.00±0.02	4.75±0.02	5.00±0.01	4.87±0.00
Arka Anamika x PBN-1	4.00±0.06	3.50±0.05	4.37±0.06	4.35±0.05	4.75±0.03	4.12±0.07
Shagun x AKO-107	4.00±0.06	3.88±0.05	4.50±0.03	4.00±0.01	5.00±0.02	4.50±0.08
Akola Bahar x PBN-13	4.50±0.03	4.37±0.05	5.00±0.03	4.62±0.02	5.10±0.02	5.00±0.02
AKO-107 x Pusa Sawani	3.88±0.05	4.62±0.07	4.50±0.02	3.95±0.03	3.50±0.05	4.87±0.02
Days to 50% flowering						
Parbhani kranti x Shagun	44.00±0.08	45.33±0.17	44.50±0.06	43.00±0.04	44.10±0.04	44.25±0.05
Arka Anamika x PBN-1	44.33±0.05	44.66±0.11	44.00±0.20	43.00±0.04	45.56±0.05	43.53±0.03
Shagun x AKO-107	45.33±0.26	43.75±0.03	44.16±0.05	44.75±0.05	43.00±0.04	43.40±0.01
Akola Bahar x PBN-13	45.66±0.08	44.51±0.06	41.66±0.11	43.50±0.19	43.25±0.01	42.20±0.04
AKO-107 x Pusa Sawani	43.75±0.03	44.33±0.11	43.25±0.05	43.49±0.03	42.85±0.04	42.99±0.07
fruit Length (cm)						
Parbhani kranti x Shagun	12.10±0.03	11.25±0.03	12.10±0.01	11.70±0.02	12.00±0.02	11.75±0.01
Arka Anamika x PBN-1	13.10±0.03	12.60±0.01	12.65±0.03	12.25±0.02	12.75±0.02	12.45±0.01
Shagun x AKO-107	11.25±0.02	13.10±0.01	13.50±0.15	12.80±0.01	12.20±0.01	13.50±0.02
Akola Bahar x PBN-13	13.40±0.02	13.30±0.03	12.75±0.02	11.95±0.01	12.85±0.02	12.50±0.01
AKO-107 x Pusa Sawani	13.10±0.03	13.40±0.02	13.25±0.02	12.60±0.01	11.95±0.01	13.00±0.06

Contd..

Character and Cross	P ₁	P ₂	F ₁	F ₂	B ₁	B ₂
fruit weight (g)						
Parbhani kranti x Shagun	17.42±0.01	15.70±0.01	17.50±0.01	16.55±0.03	17.10±0.01	16.89±0.21
Arka Anamika x PBN-1	16.20±0.35	17.95±0.04	17.65±0.01	16.25±0.02	16.60±0.02	17.72±0.01
Shagun x AKO-107	15.70±0.02	16.80±0.21	17.20±0.02	15.90±0.01	16.20±0.01	16.40±0.03
Akola Bahar x PBN-13	17.20±0.01	16.50±0.18	17.55±0.02	16.15±0.01	17.05±0.01	17.00±0.02
AKO-107 x Pusa Sawani	16.80±0.02	17.70±0.01	16.35±0.01	16.75±0.01	17.00±0.15	16.70±0.01

Diameter of fruit (cm)						
Parbhani kranti x Shagun	1.91±0.01	1.75±0.02	1.95±0.01	1.85±0.01	1.90±0.00	1.85±0.00
Arka Anamika x PBN-1	1.83±0.02	1.72±0.00	1.89±0.01	1.73±0.00	1.97±0.01	1.90±0.01
Shagun x AKO-107	1.75±0.01	1.79±0.01	1.80±0.01	1.74±0.00	1.66±0.00	1.68±0.01
Akola Bahar x PBN-13	1.86±0.00	1.79±0.00	1.83±0.00	1.77±0.00	1.85±0.00	1.78±0.00
AKO-107 x Pusa Sawani	1.79±0.00	1.84±0.00	1.80±0.00	1.76±0.00	1.76±0.00	1.80±0.00
Number of fruit per plant						
Parbhani kranti x Shagun	12.00±0.01	12.66±0.07	14.00±0.25	12.75±0.01	13.75±0.01	12.60±0.03
Arka Anamika x PBN-1	13.12±0.04	12.25±0.01	14.12±0.17	14.00±0.02	13.32±0.01	12.35±0.01
Shagun x AKO-107	12.66±0.07	12.33±0.02	13.83±0.02	13.66±0.03	14.00±0.06	13.33±0.01
Akola Bahar x PBN-13	12.00±0.05	12.33±0.09	13.50±0.09	12.83±0.01	13.25±0.01	13.75±0.01
AKO-107 x Pusa Sawani	12.33±0.04	12.10±0.01	13.75±0.02	12.66±0.01	13.00±0.11	12.82±0.01
Fruit yield per plant (g)						
Parbhani kranti x Shagun	209.04±2.88	198.75±0.89	245.00±1.59	211.03±0.74	235.16±0.04	212.80±0.43
Arka Anamika x PBN-1	212.63±0.93	219.87±3.06	249.21±0.46	227.51±0.90	221.18±0.10	218.84±0.43
Shagun x AKO-107	198.76±1.43	207.20±2.26	239.26±0.82	217.26±0.44	226.41±1.15	218.62±0.72
Akola Bahar x PBN-13	206.39±1.85	203.44±0.86	236.92±0.02	207.21±1.64	225.90±0.16	233.75±0.18
AKO-107 x Pusa Sawani	207.14±0.69	214.17±0.10	224.19±0.66	212.05±0.40	221.00±0.15	214.17±0.76
Fruit yield per hectare (q)						
Parbhani kranti x Shagun	232.26±2.83	220.84±0.98	272.22±1.77	234.45±0.82	261.23±0.06	236.44±0.48
Arka Anamika x PBN-1	236.25±4.37	244.30±0.30	276.89±0.52	253.13±1.15	245.15±0.10	243.15±0.47
Shagun x AKO-107	220.85±1.59	230.21±3.04	265.84±1.92	241.39±0.50	252.01±1.28	242.90±0.81
Akola Bahar x PBN-13	229.32±0.90	226.04±2.37	263.24±1.02	230.22±0.55	251.00±1.32	259.72±0.20
AKO-107 x Pusa Sawani	230.15±0.77	237.96±0.10	249.89±0.74	235.61±0.44	245.54±1.21	237.96±0.59

Table 3: Scaling test for different character in 5 crosses in okra

Characters and Crosses	A	B	C
Plant height (cm)			
Parbhani kranti x Shagun	3.48**±0.21	6.00**±0.36	-3.00**±0.50
Arka Anamika x PBN-1	4.00**±0.29	4.42**±0.46	-8.60**±0.44
Shagun x AKO-107	2.40**±0.54	0.89*±0.24	-4.36**±0.34
Akola Bahar x PBN-13	0.22±0.34	-4.44**±0.33	-4.10**±0.65
AKO-107 x Pusa Sawani	-8.26**±0.16	-4.32**±0.15	-12.32**±0.31
Internodal length (cm)			
Parbhani kranti x Shagun	0.20*±0.06	-0.50**±0.06	-0.30±0.12
Arka Anamika x PBN-1	-0.50**±0.06	-0.90**±0.08	-1.00**±0.17
Shagun x AKO-107	-0.80**±0.05	-0.40**±0.05	-1.40**±0.10
Akola Bahar x PBN-13	-0.80**±0.06	-0.70**±0.06	-1.30**±0.12
AKO-107 x Pusa Sawani	-1.30**±0.11	-1.00**±0.10	-0.90**±0.23
Number of branches per plant			
Parbhani kranti x Shagun	0.50**±0.10	0.74**±0.06	0.50*±0.16
Arka Anamika x PBN-1	1.13**±0.11	0.37±0.16	1.16**±0.27
Shagun x AKO-107	1.50**±0.08	0.62**±0.16	-0.87**±0.11
Akola Bahar x PBN-13	0.70**±0.06	0.62**±0.06	-0.37±0.14
AKO-107 x Pusa Sawani	-1.38**±0.13	0.62**±0.10	-1.70**±0.17
Days to 50 % flowering			
Parbhani kranti x Shagun	-0.30±0.14	-1.33**±0.22	-6.33**±0.29
Arka Anamika x PBN-1	2.79**±0.22	-1.59**±0.24	-4.99**±0.45
Shagun x AKO-107	-3.49**±0.28	-1.11**±0.06	1.59**±0.37
Akola Bahar x PBN-13	-0.82**±0.14	-1.78**±0.15	-0.49±0.80
AKO-107 x Pusa Sawani	-1.26**±0.10	-1.59**±0.19	-0.57*±0.21
Fruit length (cm)			
Parbhani kranti x Shagun	-0.20*±0.05	0.15*±0.04	-0.75**±0.10
Arka Anamika x PBN-1	-0.25**±0.05	-0.35**±0.05	-2.00**±0.11
Shagun X AKO-107	-0.35±0.15	0.40*±0.28	-0.15±0.30
Akola Bahar x PBN-13	-0.45**±0.06	-0.05±0.05	-3.40**±0.07
AKO-107 x Pusa Sawani	-2.45**±0.04	-0.65**±0.14	-2.60**±0.07

Contd..

Characters and Crosses	A	B	C
Fruit weight (g)			
Parbhani kranti x Shagun	-0.72**±0.04	0.58±0.43	-1.92**±0.14
Arka Anamika x PBN-1	-0.65±0.35	-0.16*±0.06	-4.45**±0.37
Shagun x AKO-107	-0.60**±0.05	-1.30**±0.22	-3.50**±0.22
Akola Bahar x PBN-13	-0.65**±0.06	-0.05±0.19	-4.20**±0.19
AKO-107 x Pusa Sawani	0.85*±0.31	-0.65**±0.04	-0.20*±0.15
Diameter of fruit (cm)			
Parbhani kranti x Shagun	-0.06*±0.01	-0.16**±0.03	-0.05*±0.01

Arka Anamika x PBN-1	0.22**±0.03	-0.19**±0.02	-0.41**±0.04
Shagun x AKO-107	-0.23**±0.01	-0.23**±0.01	-0.18**±0.02
Akola Bahar x PBN-13	0.01±0.00	-0.06**±0.01	-0.23**±0.01
AKO-107 x Pusa Sawani	0.50**±0.01	0.25**±0.03	-0.25**±0.11
Number of fruit per plant			
Parbhani kranti x Shagun	1.50**±0.25	-1.46**±0.26	-1.66**±0.51
Arka Anamika x PBN-1	-0.59**±0.1	-1.67**±0.17	2.38**±0.36
Shagun x AKO-107	1.51**±0.15	0.50**±0.05	2.01**±0.17
Akola Bahar x PBN-13	1.00**±0.08	1.67**±0.10	-0.01±0.16
AKO-107 x Pusa Sawani	-0.07±0.01	-0.04**±0.00	-0.19**±0.01
Fruit yield per plant (g)			
Parbhani kranti x Shagun	16.28**±3.29	-18.14**±2.02	-53.68**±5.30
Arka Anamika x PBN-1	-19.47**±1.06	-31.39**±3.21	-20.88**±4.91
Shagun x AKO-107	15.59**±2.84	-9.22**±2.81	-15.45**±3.62
Akola Bahar x PBN-13	8.49**±1.88	27.13**±0.94	-54.84**±6.90
AKO-107 x Pusa Sawani	10.04**±1.01	-10.63**±1.67	-22.72**±2.21
Fruit yield per ha. (q)			
Parbhani kranti x Shagun	17.98**±3.34	-20.17**±2.25	-59.75**±5.69
Arka Anamika x PBN-1	-21.63**±4.40	-34.89**±1.13	-21.80**±6.44
Shagun x AKO-107	17.32**±3.57	-10.24**±3.94	-17.17**±5.52
Akola Bahar x PBN-13	9.43**±2.98	30.15**±2.61	-60.95**±3.95
AKO-107 x Pusa Sawani	11.15**±2.64	-11.82**±1.40	-25.25**±2.45

*, **significance at 5% and 1 % respectively

Table 4: Mean performance of 5 crosses/ hybrids and checks for 10 characters in Okra.

Sr. No.	Hybrid/ check	Plant height (cm)	Internodal length (cm)	Number of branches per plant	Days to 50% flowering	Fruit length (cm)	Fruit weight (g)	Diameter of fruit (cm)	Number of fruit per plant	Fruit yield per plant (g)	Fruit yield per ha. (q)
I.	Parbhani kranti x Shagun	138.00	9.10	5.00	44.50	12.10	17.50	1.95	14.00	245.00	272.22
	Ankur-40	141.00	8.54	4.87	44.57	12.30	15.45	1.81	13.37	205.66	228.84
II.	Arka Anamika x PBN-1	142.00	8.20	4.37	44.00	12.65	17.65	1.89	14.12	249.21	276.89
	Ankur-40	141.00	8.55	4.85	44.37	12.28	15.42	1.81	13.39	205.66	228.84
III.	Shagun x AKO-107	140.10	8.40	4.50	44.16	13.50	17.30	1.80	13.83	239.26	265.84
	Ankur-40	141.15	8.58	4.87	44.57	12.25	15.45	1.82	13.37	205.66	228.84
IV.	Akola Bahar x PBN-13	138.50	8.60	5.00	41.66	12.75	17.55	1.83	13.50	236.92	263.24
	Ankur-40	141.00	8.55	4.88	44.32	12.25	15.42	1.81	13.37	205.66	228.84
V.	AKO-107 x Pusa Sawani	140.00	8.10	4.50	43.25	13.25	16.35	1.80	13.75	224.81	249.79
	Ankur-40	141.10	8.55	4.87	44.37	12.30	15.45	1.83	13.39	205.66	228.84

Conclusion

The crosses Parbhani kranti x Shagun and Akola Bahar x PBN-13 showed superior mean performance for fruit yield per plant. However the cross Parbhani kranti x Shagun depicted superior performance for maximum number of characters studies. Superior hybrid was developed from the combination of parents Shagun and Ako-107 and for economically important traits like fruit yield per plant compared with P₁, P₂, F₁, F₂, BC₁ and BC₂ parameter in its generation system. However, the cross Arka Anamika x PBN-1 showed superior performance compared with remaining four crosses. In most of the crosses, additive x additive type of gene action played an important role in the inheritance of days to 50 % flowering. Dominance type gene action was observed to be important in the inheritance of characters like yield per plant, plant height, fruit length and fruit diameter. Dominance type of gene action would favour for production of hybrids. Most of the characters under study showed duplicate type of gene action,

as such, transgressive variation can be obtained in the characters. Complimentary type of gene action was observed to play an important role in the inheritance fruit diameter to greater extent.

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