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EFFECT OF PLANT GEOMETRY AND GENOTYPE ON YIELD AND YIELD CONTRIBUTING TRAITS IN OKRA (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH)

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Abstract – The Present investigation was conducted during summer season, 2018 at DAV University, Jalandhar to determine most suitable variety and plant spacing for optimum production of okra in Jalandhar region. The treatments consisted of three plant spacings (30 × 5cm, 30 × 10cm, 30 × 15cm) and two varieties *viz*., Arka Anamika and Jammu Okra 05 laid in Factorial Randomized Complete Block design with three replications. Characters studied were days to 50% flowering, number of fruit per plant, number of fruit per plot, fruit yield per plot (kg), fruit length (cm), fruit diameter(cm), number of ridges per fruit, number of leave per plant and plant height(cm). Results obtained revealed that spacing and varieties has played paramount role in deciding the yield and yield contributing traits of okra. Among the varieties and spacing studied in the present investigation Arka Anamika, and spacing 30 cm × 10 cm have performed superior for most of the characteristics under observation. While, spacing 30 cm × 5cm and 30 cm ×15cm and variety of Jammu Okra 05 has manifested the undesirable results. The maximum number of fruits/plot, fruit length, plant height, number of leaves/ plant, number of fruits/ plant and total yield were witnessed at wider spacing 30 cm ×10 cm in variety Arka Anamika, while days to 50% flowering, fruit diameter was lowest in 30 cm × 15 cm in variety Arka Anamika.

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) *Moench*] commonly known as lady's finger (or bhindi in India) is a polyploid vegetable with chromosome number 2n=130. It belongs to the family Malvaceae. Okra has originated from Ethiopia and Africa (Khalid *et al*., 2005) and was first cultivated by Egyptians in the 12th century (Thompson *et al*., 1997). It is widely cultivated throughout the tropics and sub tropics, as well as in the warmer parts of the temperate regions (Farinde *et al*., 2007). In India, okra is cultivated over an area of 509 thousand hectares, with annual production and productivity of 6095 thousand MT and 12 MT/hectare (Anonymous, 2018a). However, in Punjab it is cultivated over an area of about 4.57 thousand/hectare with a production and productivity of 47.65 MT and 10.42 MT/hectare (Anonymous, 2018b). Okra is commercially cultivated for its tender fruits or pods. It is a nutritious vegetable and rich source of carbohydrates, proteins, vitamins (A, B, C) calcium, potassium, dietary fibers and minerals like iodine and calcium, hence, playing a vital role in the human diet (Rashwan, 2011). The growth, yield and quality of okra is hampered severely by inefficient production methods or lack of knowledge about the best cultivation and management practices, low quality seed standards and limited market access. Its production and productivity are also seriously affected due to the use of local varieties, sub or supra-optimal plant density, inappropriate planting dates, soil nutrients, and severe attack of various insect pests, diseases and weeds (Saha *et al*., 1989). The planting density plays a significant role in okra cultivation. Lack of optimum plant spacing results in poor growth, low yield and poor quality fruits while, high plant density may lead to vigorous growth, poor quality fruits and low yield due to intra specific competition, (Moniruzzuman *et al*., 2007). The use of spacing in crop production is very important, because it reduces competition between plants and weeds. Increased spacing reduces the number of plants per hectare thus affecting the

yield. However, decreased spacing increases plant population and yield per unit area up to a certain limit, beyond which the yield decreases due to limitation in utilization of natural resources required for plant growth. (Zibelo *et al.*, 2016).

Some varieties of okra are tall, while others are dwarf, because of which variation in their performance is often observed (Dikwahal *et al.*, 2006). Farmer cultivates okra without adequate knowledge about the appropriate spacing for optimum yield. Furthermore, seasonal long duration local varieties with low yielding ability are still in use. New varieties capable of withstanding stress, giving higher yields along with other desirable traits are now available and should be adopted. Okra is an important crop in India and different varieties are used by farmers in order to meet the market demand. These varieties have varying response to soil type, season and spacing. Different cultivars of okra require different plant spacing. A good cultivar sown with an improper spacing would yield poorly. Therefore, proper plant spacing of suitable cultivars is critical to increased production of okra. Arka Anamika is one of the most popular variety of okra in Punjab region and Jammu Okra -05 is newly released variety of SKUAST-Jammu for Jammu region. Since, the climatic conditions of Jammu are almost similar to that of Jalandhar. Therefore, Jammu Okra-05 is included in the present study to determine most suitable variety and plant spacing for optimum production of okra in Jalandhar region. Keeping in view the importance of suitable varieties and spacing, the present investigation was conducted To study the effect of spacing, varieties and their interaction on yield and yield contributing traits in okra.

MATERIALS AND METHODS

The experiment was carried out on okra during summer season, 2018 at the Agricultural Farm of DAV University, Sarmastpur, Jalandhar. The farm is situated at elevation 243 meters above mean sea level and located in 31.33 latitude and 75.58 longitudes above the mean sea level which falls under the transgangetic plains of Punjab. The experiment was laid out in Factorial Randomized Complete Block Design with three replications. Three plant spacings i.e. 30cm × 5cm, 30cm × 10cm and 30cm × 15cm and two varieties Arka Anamika and Jammu okra 05 and their interaction were studied. The cultural operations were carried out as and when required. Five competitive plants were selected randomly from each plot avoiding the border rows for the purpose of recording observations. The data was recorded on varying characters like, Days to 50% flowering, number of fruits per plant, number of fruit per plot, fruit yield per plot, fruit length (cm), fruit diameter (cm), fruit ridges and plant height (cm). The statistical analysis of data recorded during the course of investigation for all the characters was done by analysis of variance method for factorial randomized block design described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Analysis of Variance (ANOVA) revealed significant difference among varieties and intraction effects of varieties and spacings for all the characters except Fruit yield per plot (Kg) and number of ridges per fruit. Spacing also showed significant difference for all the characters except number of ridges per fruit. (Table 1)

Days to 50 % flowering

Significantly less number of days to 50% flowering (46.66) were recorded in S_2 (30cm × 10cm) and S_3 (30cm × 15cm) which indicates early flowering in wider spacing. These results are in agreement with the results of Talukder *et al*. (2003) who also observed 50% flowering from moderate spacing. Saha *et al*. (2005) who suggested that wider spacing provides less competition between plants for growth and its yield attributes and plant mature faster and take less number of days for 50% flowering. Zibelo *et al*. (2016) also observed minimum days to 50% flowering in (30 cm × 15 cm) spacing in okra.

The significant effect of varieties on days to 50% flowering might be due to the differences in the plants life cycle as some varieties matures earlier than others. Similarly, growth resources might have been utilized differently by these varieties. The results of present investigation are in line with Yusuf and Muhamman (2017) who also observed significant difference for days to 50% flowering among different varieties.

Interaction effect of spacing × variety on days to 50% flowering revealed that $V_2 \times S_2$ (Jammu Okra 05 × 30 cm × 10 cm) took minimum days to 50% flowering to the tune of (45.66) which was statistically at par with $V_1 \times S_3$ (30 cm × 15 cm × Arka

Anamika). These results are in corroboration with the results of Talukder *et al*. (2003); Saha *et al*. (2005) and Zibelo *et al*. (2016). (Table 2)

Number of fruits per plant

Significant differences for number of fruits per plant were observed among varieties under study which can be attributed to the genetic makeup of these varieties. These finding are similar to the findings of Aliyu and Ajala (2016) and Yusuf and Muhamman (2017) who also observed significant differences for number of fruits per plant among different varieties under study.

The number of fruits per plant is an important factor to increase the yield (Singh, 1996). Highest number of fruits per plant (24.66) was recorded in S_2 (30 × 10 cm) and S_3 (30 × 15 cm) in the present investigation. These findings are in agreement with the findings of Parmar *et al*. (2016) and Zibelo *et al*. (2016) who reported greater number of fruits per plant in wider spacing in okra. As okra bears single flower per node which in turn is influenced by number of branches per plant. Narrower spacing result increased in competition among adjoining plants for available soil nutrients and water as well as for canopy formation. This prevents profuse branching and production of nodes per plant. Therefore there will be fewer numbers of fruiting nodes in higher plant densities and vice versa.

The combination $V_2 \times S_2$ (Jammu Okra-05 × 30 cm × 10 cm) produced maximum number of fruits per plant (25.00) which was statistically at par with $V_1 \times S_2$ (Arka Anamika × 30cm × 10 cm) in the present investigation. This depicts that both the cultivars responded well to the wider spacing. These results corroborates with earlier researchers *viz*., Parmar *et al*. (2016); Zibelo *et al*. (2016) and Kumar *et al.* (2016). (Table 2).

Number of fruits per plot

Number of fruits per plot showed similar trends as that of Number of fruits per plant. The findings are in conformity with the findings of Gorachand *et al*. (1990) and Kumar *et al*. (2016).

Fruit yield per plot

Fruit yield per plot are influenced by other factors like number of pods per plot, fruit diameter and fruit length etc. The results observed for fruit yield per plot were same as the results observed for these characters in the present investigation. However, there was no significant difference among the spacing for the fruit yield per plot in the present investigation. These results are similar to the findings of Singh (2003) and Okunowo (2012) who also reported no significant effect of different spacings on fruit yield.

Observed significant differences for fruit yield per plot among different varieties under study can be attributed to the genetic potential of these varieties. Gautam *et al*. (2004) also reported the same.

Non significant differences for fruit yield per plot were observed in the study, in contradicting to the findings of Aliyu and Ajala (2016) and Kumar *et al*. (2016). The conflicting results might be due to the variation in the environment and differences in the genetic potential of the varieties used by these researchers (Table 2).

Fruit length

Increased fruit length was reported with the

Table 1. Effect of interaction of plant geometry and genotype on yield and yield contributing traits in okra

Treatment	Days to 50% flowering	Number of fruits per plant	Number of fruit per plot	Fruit yield per plot (Kg)	Fruit length (cm)	Fruit diameter (cm)	Number of ridges per fruit	Number of leaves per plant	Plant height (cm)
Varieties									
V_1	47.33	24.44	567.44	4.20	8.30	1.06	4.97	11.12	60.13
V_2	46.56	23.67	528.66	3.62	8.33	1.05	5.07	11.32	60.68
CD (5%)	0.59	0.53	25.92	0.27	0.001	0.005	N.S	0.07	0.04
SE(d)	0.26	0.23	11.62	0.12	0.005	0.002	0.05	0.03	0.02
Plant spacing									
S_1	47.50	23.83	528.74	3.84	8.24	1.07	5.03	11.26	60.52
S_2	46.66	24.66	547.16	4.32	8.36	1.05	4.94	10.91	60.68
S_3	46.66	24.66	547.16	3.74	8.34	1.07	5.10	11.48	60.01
CD (5%)	0.72	0.65	14.42	N.S	0.001	0.007	N.S	0.08	0.05
SE(d)	0.32	0.29	14.25	0.15	0.006	0.003	0.21	0.04	0.02

increase in intra-plant spacing. It was observed that S_2 (30 ×10 cm) resulted in maximum fruit length (8.36cm) which was statistically higher than all other spacings. These findings are in agreement with the finding of Kumar *et al.* (2016) who also observed highest fruit length in spacing (30 × 10 cm). Narrow spacing give the higher competition for all the resources factors to the plant but in wider spacing competition will be less and plant and its parts become healthier (Saha *et al.* 2005).

Varieties also resulted in significant differences for fruit length which may be due their genetypic differences. These finding are similar to the findings of Rashwan (2011); Singh and Aminu *et al*. (2016) who also observed significant differences for fruit length among different varieties under study.

In the present investigation longest fruits (8.36cm) were observed in $V_1 \times S_2$ (Arka Anamika × 30cm × 10cm) which were statistically at par with $V_2 \times S_3$ (Jammu Okra-05 × 30cm × 15cm) 8.36cm, $V_2 \times S_2$ (Jammu okra-05 × 30cm × 10cm) 8.36cm, and $V_1 \times S_3$ (Arka Anamika 30cm × 15cm) 8.34cm. The results are in contradiction to the findings of earlier researcher Kumar *et al.,* (2016) who reported non significant interaction effects of varieties and spacing for fruit length. But in line with the findings of Aliyu and Ajala (2016). This may be due to the fact that difference in varieties may have contributed more towards the interaction effects for fruit length in the present investigation. (Table 2)

Fruit diameter (cm)

Fruit diameter in one of the major criteria to judge okra yield and preferable pod size. Bigger and longer green pods are preferred and market appealing character of okra (Moniruzzaman *et al*. 2007). Significantly lower fruit diameter (1.05 cm) was observed in plants grown in spacing S_2 (30 cm × 10 cm). In general, the bigger fruit diameter and longer fruits size, the more is the yield. The spacing which produced fruit with higher diameter also produced higher yield in the present investigation which are in line with the findings of Zibelo *et al*. (2016).

Genotypic differences resulted in significant difference among varieties for fruit diameter. These findings are in accordance to the findings of Kumar *et al*. (2016)

Significant differences for fruit diameter were observed among the interaction effects of varieties and spacing. The results are in line with the findings of Kumar *et al*. (2016) who also reported significant interaction effects of varieties and spacing for fruit diameter (Table 2).

Number of ridges per fruit

Highest number of ridges per fruit (5.07) was recorded in V_2 (Jammu Okra-05) which was statistically highest than the number of ridges per fruit produced in V_1 (Arka Anamika) 4.97. Among spacings studied in the present investigation highest number of ridges per fruit (5.10) was recorded in S_3 (30 cm × 15 cm) and lowest number of ridges per fruit was recorded in S_2 (30 cm × 10 cm), i.e. 4.94.

Interaction between varieties and spacing for number of ridges per fruit showed no significant difference. However, maximum number of ridges per fruit was observed in case of $V_2 \times S_2$ (Jammu Okra-05 × 30 cm × 10 cm) i.e. 5.13 and minimum number of ridges per fruit was recorded in $V_1 \times S_2$ (Arka Anamika × 30 cm ×10 cm) i.e. 4.94. (Table 2)

Number of leaves per plant

Number of leaves per plant is an important parameter considering the highest performance of okra yield (Gupta and Shukla, 2000). As more the

Table 2. Effect of interaction of plant geometry and genotype on yield and yield contributing traits in okra

Interaction	Days to 50% flowering	Number of fruits per plant	Number of fruit per plot	Fruit yield per plot (Kg)	Fruit length (cm)	Fruit diameter (cm)	Number of ridges per fruit	Number of leaves per plant	Plant height (cm)
V_1XS_1	47.50	23.83	561.50	3.84	8.24	1.07	5.03	11.26	60.52
V_1XS_2	46.66	24.66	547.16	4.32	8.36	1.05	4.94	10.91	60.68
V_1XS_3	46.66	23.66	535.50	3.74	8.34	1.07	5.10	11.48	60.01
V_2XS_1	47.33	22.33	524.66	3.45	8.27	1.06	5.00	11.46	61.02
V_2XS_2	45.66	25.00	584.66	3.97	8.36	1.05	5.13	11.00	60.99
V_2XS_3	46.66	22.66	476.66	3.46	8.36	1.06	5.09	11.50	60.03
CD (5%)	1.03	0.91	44.89	N.S	0.02	0.01	NS	0.12	0.07
SE(d)	0.46	0.41	20.16	0.21	0.008	0.004	0.09	0.05	0.03

number of leaves more will be the photosynthetic produced. In the present investigation significantly highest number of leaves per plant (11.48) was recorded in S_3 (30 cm × 15 cm) which means, wider spacing resulted in more number of leaves per plant. These findings corroborates with the finding of Zibelo *et al*. (2016); Shukla *et al.* (2018) Gbaraneh (2018) who also reported higher number of leaves per plant in wider plant spacing.

Number of leaves per plant varied with the genotype in the present investigation which may be due to their genotypic differences. These findings are in accordance with the findings of Alam and Hossain (2008) and Sisodiya (2014) who also reported significant differences for number of leaves per plant among different genotypes (Table 2)

Plant height (cm)

S_2 (30 cm × 10 cm) produced tallest plants (60.68 cm) which were significantly taller than the height of plants observed in the treatment of S_3 (30 cm × 15 cm) (60.01 cm) and S_1 (30 cm × 5 cm) (60.52 cm). This indicates a decreasing trend of plant height with the increase in inter-plant spacing. These findings are in line with the findings of Soni *et al*. (2006), Morwal and Patel (2017) and Gbaraneh (2018) who also reported taller plants in narrow plant spacing.

Significant difference among varieties for plant height was observed in the present investigation. These reports are similar to the findings of earlier researchers *viz*., Jayapandi and Balkrishnan (1992); Chitra (1999); Aliyu and Ajala (2016) and Kumar *et al*. (2016).

Interaction effect of spacing and varieties was significant for plant height. Kumar *et al*. (2016) also reported similar results for plant height. (Table 2)

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