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Effect of Spacing and Plant Growth Regulators on Plant Growth Parameters, Seed Yield and Its Attributes in Okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

The present investigation entitled "Effect of spacing and plant growth regulators on plant growth parameters, seed yield and its attributes of okra [Abelmoschus esculentus (L.) Moench]" was conducted for two consecutive seasons (kharif 2015 and kharif 2016). Seeds of okra variety GJO 3 were treated with aqueous solution of growth regulators viz., GA_3, IBA and NAA, each at 50, 100 and 150 ppm concentrations and without growth regulators (water soaking). The growth regulators were applied as seed soaking treatment for 8 hours. A treated seeds were grown in field with three plant spacing (S_1 : 45 cm × 30 cm, S_2 : 60 cm × 30 cm and S_3 : 60 cm × 45 cm) during kharif 2015 and 2016 at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh in Split Plot Design (Factorial) replicated thrice. Three plant spacing were kept in main plots and seed treatments with growth regulators along with different doses and a control (water soaking) were kept in sub-plots. Observations were recorded on plant growth parameters viz., field emergence, plant height (cm), stem diameter (cm) and number of branches per plant; and seed yield and its attributes viz., days to flower initiation, number of fruits per plant, fruit length (cm), fruit thickness (cm), number of locules per fruit, number of seeds per fruit and seed yield per plant (g). All plant growth parameters, seed yield and its attributes studied were significantly influenced by different plant spacing and application of different plant growth regulators as seed treatment prior to sowing, except field emergence and days to flower initiation during both the years of experimentation (kharif 2015 and 2016) and fruit length in pooled over years due to spacing. Interactions effects of spacing and seed treatments (S x T) with growth regulators were found significant for field emergence, number of branches per plant, fruit length and fruit thickness during kharif 2015; for fruit length and fruit thickness during kharif 2016; and for field emergence in pooled over years. Wider spacing of 60 cm x 45 cm (S_3) and seeds treated with GA_3 150 ppm (T_3) recorded significantly the maximum values for growth parameters viz., plant height, stem diameter and number of branches per plant; seed yield and yield attributes viz., seed yield per plant, number of fruits per plant, fruit thickness and number of seeds per fruit. A combination of wider plant spacing 60 cm x 45 cm and seed treatment of GA_3 @ 150 ppm before sowing (S_3T_3) was found best suited combination, as it has good field emergence and produced significantly and/or comparatively the maximum plant height, stem diameter, number of branches per plant, number of fruits per plant, fruit length, fruit thickness, number of seeds per fruit and seed yield per plant.

Key words: *GA_3, growth regulators, IAA, NAA, okra, spacing, viability*

INTRODUCTION

Okra *Abelmoschus esculentus* L. (Moench), is an economically important vegetable crop grown in tropical and sub-tropical parts of the world[41]. It is commonly known as bhindi or lady's finger belonging to family Malvaceae. It is an important fruit vegetable crop cultivated in various states of India. Several species of the genus *Abelmoschus* are grown in many parts of the world among them *Abelmoschus esculentus* L. (Moench) is most commonly cultivated in Asia and has a great commercial demand due to its nutritional values. During 2013-14, okra is gown in the world on an area of 11.17 lakh hectares with a production of 8.71 million tonnes and productivity of 7.8 t/ha[2]. India ranks first in the world with 6.35 million tonnes (around 70 per cent of the total world production) of okra produced from over 5.33 lakh hectares land with a productivity of 11.9 t/ha during 2013-14[1]. In Gujarat, okra is grown during 2013-14 on an area of 0.66 lakh hectares with a production of 0.76 million tonnes and productivity of 11.50 t/ha[1].

The seed is the prime factor that determines the quantitative and qualitative characteristics of the crop that is going to be harvested later. Therefore, more attention must be directed towards increasing seed yield with good quality. Successful production of okra seed is conditional to certain agricultural practices. To meet the requirement of increasing population, the production of okra must be stepped-up considerably. The production can be increased by two means, first by bringing more area under cultivation, which is not possible at present and second by increasing the productivity, which can be possible through development of high yielding varieties and through agronomical/physiological manipulations.

The density of plant population is an important factor, which affect the growth, yield and quality of crops, by efficient utilization of field conditions. It also determines optimum seed rate and improve the value of seed economy. Plant spacing has been found to have an enhancing influence on yielding ability and quality of seed[10,14,19,33]. Plant growth regulators considered as a new generation of agrochemicals when added in small amounts can bring the changes in the phenotypes of plants and affect growth either by enhancing or by stimulating the natural growth regulatory systems from seed germination to senescence[5]. These can improve the physiological efficiency of plants including photosynthetic capacity and effective partitioning of assimilates, resulting into increase in yield. Several reports also indicated that, plant growth regulators effect not only on accelerating germination or growth, but also help in the augmentation of produce[11,21]. Use of plant growth regulators has become one of the most important tools in the hand of horticulturists to produce maximum yield. Recently wide range of techniques of applying plant growth regulators are in practice. Among them, seed treatment with plant growth regulator is one of the most popular methods and has been claimed as the effective tool for improving rate of germination, increase in growth of shoot and root, increasing vegetable growth and seed yield[27].

Keeping this view in mind, an experiment was planned to know the proper density of plants and the optimum dose of plant growth regulators for improving plant growth characters, seed yield per plant and its attributes in okra.

MATERIALS AND METHODS

The study entitled "Effect of spacing and plant growth regulators on seed yield and seed quality parameters of okra [*Abelmoschus esculentus* (L.) Moench]" Seeds of okra variety GJO 3 were treated with aqueous solution of growth regulators *viz*., GA_3, IBA and NAA, each at 50, 100 and 150 ppm concentrations and without growth regulators (water soaking).

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The growth regulators were applied as seed soaking treatment for 8 hours. A treated seeds were grown in field with three plant spacing (S_1: 45 cm × 30 cm, S_2: 60 cm × 30 cm and S_3 : 60 cm × 45 cm) during *kharif* 2015 and 2016 at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh in Split Plot Design (Factorial) replicated thrice. Three plants spacing were kept in main plots and seed treatments with growth regulators along with different doses and a control (water soaking) were kept in sub-plots. Observations were recorded on plant growth parameters *viz*., field emergence, plant height (cm), stem diameter (cm) and number of branches per plant; and seed yield and its attributes *viz*., days to flower initiation, number of fruits per plant, fruit length (cm), fruit thickness (cm), number of locules per fruit, number of seeds per fruit and seed yield per plant (g). The data were subjected to statistical analysis of variance following Split Plot Design for individual year as well as polled over years as per the statistical procedure described by Steel and Torrie[39].

RESULTS AND DISCUSSION

Effect of plant spacing on plant growth parameters, seed yield and its attributes in okra

The analysis of variance was carried out for the experimental design (Split Plot Design) for plant growth parameters, seed yield per plant and its attributes revealed the existence of significant difference among plant spacing for all the plant growth characters, (field emergence, plant height, stem diameter and number of branches per plant), seed yield per plant and its attributes studied during both the years of experimentation (*kharif* 2015 and 2016) as well as pooled over years, except field emergence and days to flower initiation during *kharif* 2015 and 2016, and for fruit length in pooled analysis (Table 1).

During *kharif* 2015, plant spaced with S_2 (60 cm x 30 cm) noted comparatively the maximum field emergence (95.67 %) followed by S_1 (45 cm x 30 cm) (95.34 %) and S_3 (60 cm x 45 cm) (94.21 %), while during *kharif* 2016, plants spaced with S_1 (45 cm x 30 cm) noted relatively the maximum field emergence (95.90 %) followed by S_2 (60 cm x 30 cm) (95.30 %) and S_3 (60 cm x 45 cm) (94.83 %). Pooled over years, plants spaced with S_1 (45 cm x 30 cm) and S_2 (60 cm x 30 cm) were at par with each with respect to field emergence (95.62 and 95.48 %), but noted significantly the higher field emergence in comparison to S_3 (60 cm x 45 cm) (94.52 %) (Table 2). The widest spacing of 60 cm × 45 cm (S_3) recorded significantly the highest plant height (64.72, 64.75 and 64.74 cm), stem diameter (1.83, 1.61 and 1.72 cm) and number of branches per plant (2.12, 2.51 and 2.32) during both the years of experimentation and pooled over years, while closer spacing of 45 cm × 30 cm (S_1) registered the lowest plant height (57.15, 55.74 and 56.45 cm), stem diameter (1.54, 1.39 and 1.47 cm) and number of branches per plant (1.60, 1.87 and 1.73) during both the years of experimentation and pooled over years (Table 3, 4 and 5). The increased plant height in wider spacing may be due to less competition for nutrient and sun light. Increase in stem diameter and number of branches also in wider spacing was due to more space for plant spreading. Wider plant spacing reduced the competition for light and other resources as well as reduced overlapping from adjacent okra plants within the population could have enabled the plants to utilize their energy for maximum branching. Sonu *et al*[38]., Madisa *et al*[15]. and Kumar *et al*. reported that increase in plant spacing increased the plant height and they observed the highest plant height at wider spacing in okra. The highest field emergence was noted under wider spacing by Singh[36] and El-Waraky[9] in okra. The highest stem diameter and number of branches per plant in okra were observed at wider spacing by Singh[36], Maurya *et al*[17]., El-Waraky[9] and Madisa *et al*[15].

Plants spaced with 60 cm x 45 cm (S_3) recorded significantly the highest seed yield per plant (30.14, 29.93 and 30.04 g) during both the years of experimentation (*kharif* 2015 and 2016) and pooled over years. Significantly the lowest seed yield per plant (19.22, 20.70

and 19.96 g) was recorded by plant spaced at 45 cm x 30 cm (S_1) during both the years of experimentation (*kharif* 2015 and 2016) and pooled over years. Plants spaced at 60 cm x 30 cm (S_2) recorded the seed yield per plant of 24.47g, 25.01g and 24.74g during *kharif* 2015, *kharif* 2016 and pooled over years, respectively (Table 11). The highest seed yield per plant was recorded at wider spacing may be attributed to greater availability of nutrients, moisture and photosynthesis leading to better vegetative growth increased number of flowers, fruits and seed set with proper size and shape of seed. The high seed yield in okra at wider spacing was reported earlier by Moniruzzaman *et al*[19]., Philip *et al*[30]., Sharma *et al*[33]., Maurya *et al*[17]., El-Waraky[9] and Madisa *et al*[15].

Comparatively the highest number of days to flower initiation (41.89 and 41.08 days) were registered in 60 cm x 45 cm spacing (S_3) during both the years of experimentation followed by 60 x 30 cm spacing (S_2) (40.94 and 40.70 days) and 45 cm x 30 cm spacing (S_1) (40.40 and 40.13 days). In pooled analysis, number of days to flower initiation was noted significantly the highest (41.48 days) in the plant spacing of 60 cm x 45 cm (S_3) over 45 cm x 30 cm spacing (S_1) (40.27 days), but it was at par with 60 cm x 30 cm spacing (S_2) (40.82 days) (Table 6). Muhammad *et al*[20]. reported that plant spacing had non-significant influence on days taken to flowering in okra. Singh[36], Sonu *et al*[38]., and Singh and Kumar[34] observed the maximum days to flowering in okra under wider spacing followed by medium and closer spacing.

Plant spacing of 60 cm x 45 cm (S_3) produced significantly the highest number of fruits per plant (7.69, 7.63 and 7.66) over other spacing during both the years of experimentation (*Kharif* 2015 and 2016) and in pooled over years. Number of fruits per plant recorded in spacing 45 cm x 30 cm (S_1) (6.61) and 60 cm x 30 cm (S_2) (7.01) were at par with each other during *kharif* 2016 (Table 7). The higher number of fruits per plant observed in the present study with wider spacing might be due to availability of greater amount of nutrients and light per unit area resulting in better vegetative growth with more number of flowers and fruits per plant. The results of present investigation with wider spaced plants resulting in higher number of fruits per plant agree with Philip *et al*[30]., Singh[36], Sharma *et al*[33]. and Parmar *et al*[24]. in okra.

Significantly the highest fruit length (19.42 and 18.40 cm) and the lowest fruit length (13.24 and 15.38 cm) were recorded in 60 cm x 45 cm (S_3) and 45 cm x 30 cm (S_1), respectively during both the years of experimentation. Fruit length recorded during *kharif* 2016 in plant spaced at 45 cm x 30 cm (S_1) and 60 cm x 30 cm (S_2) were at par with each other (Table 8, 9 and 10). In pooled results, comparatively the highest (18.91 cm) and the lowest (14.31 cm) fruit length was recorded in plant spaced with 60 cm x 45 cm (S_3) and 45 cm x 30 cm (S_1), respectively (Table 7). Similar results of high fruit length at wider spacing were reported by Singh[36], Sonu *et al*[38]., Madisa *et al*[15]. and Parmar *et al*[24]. Significantly the highest fruit thickness (1.86, 1.85 and 1.86 cm) and number of seeds per fruit (63.91, 63.23 and 63.57) were recorded by plant spaced widely at 60 cm × 45 cm (S_3) (Table 9 and 10). Higher fruit thickness at wider spacing was noted by Singh[36], Madisa *et al*[15]., and Parmar *et al*[24]. while higher number of seeds per fruit was recorded at wider spacing by Singh[36], Sonu *et al*[38]. and Parmar *et al*[24].

Effect of plant growth regulators on plant growth parameters, seed yield and its attributes in okra

The analysis of variance revealed the existence of significant difference among growth regulators for plant growth characters, seed yield per plant and its attributes studied (Table 1).

Seeds treated with GA_3 150 ppm (T_3) recorded significantly the highest field emergence (98.77, 99.15 and 98.96 %), plant height (71.45, 67.64 and 69.55 cm), stem diameter (1.98, 1.66 and 1.82 cm) and number of branches per plant (2.93, 2.76 and 2.84) during both the years of experimentation and

pooled over years**.** Seeds treated with NAA 150 ppm (T_9) recorded significantly the lowest field emergence (90.66, 92.62 and 91.64 %) during both the years of experimentation and pooled over years (Table 2, 3, 4 and 5)**.** Seeds without treatment with growth regulators (control) (T_{10}) recorded significantly the lowest plant height (47.72, 46.82 and 47.27 cm), stem diameter (1.47, 1.35 and 1.41 cm) and number of branches per plant (0.93, 1.28 and 1.11) during both the years of experimentation and pooled over years**.** This response of GA_3 might be due to the fact that gibberellic acid (GA_3) increases the stimulation of protoplasmic streaming, cell membrane permeability to water, synthesis and activity of enzymes, proteins and nucleic acid, formation of energy rich phosphate (ATP) and cell wall plasticity and decreases the viscosity and wall pressure[12,37]. The present finding indicated that growth regulator GA_3 is involved in increasing efficient transportation, utilization of photosynthetic product, rapid cell elongation and cell division in the growing portion of plant or stimulation of growth besides increasing uptake of nutrient[23,37]. Similar results were reported earlier in okra by Patil *et al*[29]., and Patil *et al*[26]. for field emergence; Singh and Singh[35] for field emergence, plant height and number of branches per plant; Patil *et al*[27]., Singh[36] and Mohammadi *et al*[18]., for field emergence and plant height; Patil and Patel[28] and Dwivedi *et al*[8]. for field emergence and number of branches per plant; and Patil and Patel[28] for stem diameter in okra.

Seeds treated with GA_3 150 ppm (T_3) was found significantly superior and producing the highest seed yield per plant (33.10, 33.44 and 33.27 g) during both the years of experimentation (*kharif* 2015 and 2016) and pooled over years (Table 11). Seeds treated with IBA 150 ppm (T_6) was the next best treatment producing the seed yield per plant of 28.94g, 29.42g and 29.18g during *kharif* 2015, *kharif* 2016 and pooled over years, respectively. Seeds soaked in water (T_{10}) produced significantly the lowest seed yield per plant (14.71, 17.68 and 16.19 g) during both the years of experimentation and in pooled over years. The increase in seed yield per plant due to GA_3 growth regulators may be due to influence on better growth of plant, number of branches per plant, length of fruits, number of fruits, higher number of fruits per plant and well seed set, lower flower and fruit drop, proper size and shape, lower damage and shrivelled seeds. Bhagure and Tambe[4] reported that soaking of okra seeds with GA_3 @ 100 ppm recorded significantly the highest seed yield per plant. The results obtained under the present study were similar to those reported in okra earlier by Singh and Singh[35] (1977), Omran *et al*[22]. Patil *et al*[29]., Patil *et al*[27]., Patil *et al*[26]., Ayyub *et al*[3]. and Patil *et al*[25]. in okra.

Seeds treated with GA_3 150 ppm (T_3) recorded significantly the minimum days to flower initiation (37.61, 37.56 and 37.59 days) during both the years of experimentation and pooled over years and it was at par with T_2 (GA_3 100 ppm) (38.89 days) during *kharif* 2015 and with T_2 (GA_3 100 ppm) (38.10 days) and T_1 (GA_3 50 ppm) (38.22 days) during *kharif* 2016. Seeds soaked in water (T_{10}) noted significantly the maximum days to flower initiation (43.89 and 43.37 days) during *kharif* 2016 and pooled over years, while in *kharif* 2015, significantly the maximum days to flower initiation was registered in T_7 (NAA 50 ppm) (43.42 days) (Table 6). This result may be due to that, GA_3 is well known for vegetative growth of the plant and it promotes earliness in growth and earliness in flower initiation, but auxins (IBA and NAA) delayed vegetative growth automatically days to flower initiation may delayed. This finding has been supported by Singh and Kumar[33], who reported that okra cv. Pusa Sawani was treated with GA_3 advanced the flowering by 6.33 days compared with the untreated control. Ravat and Makani[32] reported that application of GA_3 @ 150 ppm as seed treatment was the best treatment for flower initiation.

Seeds treated with GA_3 150 ppm (T_3) was found significantly superior with respect to number of fruits plant (8.32, 8.34 and 8.33), fruit length (17.54, 17.77 and 17.66 cm), fruit

thickness (1.91, 1.94 and 1.92 cm) and number of seeds per fruit (63.91, 63.23 and 63.57) during both the years of experimentation as well as in pooled over years, while seeds soaked in water (control) (T_{10}) produced significantly the lowest number of fruits per plant (5.87, 5.89 and 5.88), fruit length (14.89, 15.33 and 15.11 cm), fruit thickness (1.55, 1.60 and 1.57 cm) and number of seeds per fruit (53.93, 53.58 and 53.76) in both the years of experiment and in pooled results (Table 7, 8, 9 and 10). The increase in number of fruits per plant may be due to involvement of GA_3 in inhabitation of cellulose and pectinase activity and abscission production thereby decreasing the premature fruit drop. Further, the growth regulators are also involved in the process of ovary development. The increase in fruit length and thickness due to GA_3 may be related to more efficient mobilization, utilization of nutrient and assimilates with higher rate of cell division and cell elongation. The possible interpretation of increasing in number of fruits per plant could be attributed to the stimulating effect of GA_3 on the complete growth of the plant, which resulted in the formation of larger quantities of synthesized products, so that assimilates are distributed to pods[16]. GA_3 @ 150 ppm recorded significantly the highest number of fruits per plant due to increase in photosynthetic activity produces more carbohydrates which directly influenced the fruit size, number of fruit and ultimately final yield[7]. The results obtained in the present study for the yield attributes like number of fruits per plant, fruit length, fruit thickness and number of seeds per fruit are in akin to those reported by Kumar *et al*[13]. and Patil *et al*[25]. for number of fruits per plant and number of seeds per fruit; Singh[36] and Patil and Patel[28] for number of fruits per plant, fruit length and fruit thickness; *Surendra et al*[40]. *for* number of fruits per plant, fruit length and number of seeds per fruit; and Bhagure and Tambe[4] and Rani *et al*[31]. for number of fruits per plant.

Interaction effects of plant spacing and plant growth regulators on plant growth parameters, seed yield and its attributes in okra

Mean squares due to interaction effects of spacing × seed treatments with growth regulators were found significant for field emergence, number of branches per plant during *kharif* 2015; for fruit length and fruit thickness during both the years of experimentations; and for field emergence in pooled over years (Table 1).

Seeds treated with GA_3 150 ppm and plant spacing of 60 cm x 30 cm (S_2T_3) recorded significantly the highest field emergence (99.07 %) during *kharif* 2015, while in pooled over both the years, seeds treated with GA_3 150 ppm and plant spacing 60 cm x 45 cm (S_3T_3) recorded significantly the highest field emergence (99.31 %). During *kharif* 2016, seeds treated with GA_3 150 ppm and plant spacing of 60 cm x 45 cm (S_3T_3) recorded the highest field emergence (100.00 %) (Table 2). Similar interaction effect for field emergence was reported by Singh[36] in okra.

Plant spacing of 60 cm x 45 cm and seeds treated with GA_3 150 ppm (S_3T_3) noted comparatively the highest plant height (75.25, 75.00 and 75.13 cm) and stem diameter (2.19, 1.83 and 2.01 cm) during both the years of experimentation as well as pooled over years, whereas relatively the lowest plant height (42.00, 44.00 and 43.00 cm) and stem diameter (1.31, 1.30 and 1.31 cm) were recorded by plant spaced with 45 cm x 30 cm and water soaked seeds (S_1T_{10}) during both the years of experiment as well as pooled over years (Table 3 and 4).

Plant spaced with 60 cm x 45 cm and seeds treated with GA_3 150 ppm (S_3T_3) recorded significantly the highest number of branches per plant (3.67) during first year of experiment (*kharif* 2015), while during the second year (*kharif* 2016) and pooled over both the years, the same treatment (S_3T_3) recorded comparatively the higher number of branches per plant (3.07 and 3.37). Similarly, plant spaced with 45 cm x 30 cm spacing (S_1) recorded significantly the lowest number of branches per plant (0.80) during first year of

experiment (*kharif* 2015), while during the second year (*kharif* 2016) and pooled over both the years, the same treatment (S_3T_3) recorded comparatively the lowest number of branches per plant (1.13 and 0.97) (Table 5). Similar interaction effects for these traits were reported by Singh[36] in okra. Desai[6] recorded the maximum number of branches per plant in okra plants under wider spacing subjected to growth retardant treatment of CCC @ 1000 ppm at 30 DAS. He also observed non-significant interaction for number of branches per plant and plant height.

Plant spacing of 60 cm x 45 cm and seeds treated with GA_3 150 ppm (S_3T_3) produced relatively the highest seed yield per plant (40.67, 42.00 and 41.33 g) during both the years of experimentation and in pooled over years. Plant spaced with 60 cm x 30 cm with IBA 150 ppm (S_3T_6) and NAA 150 ppm (S_3T_9) were the next best treatment combinations producing the seed yield per plant of 35.73, 35.86 and 35.80 g and 35.15, 34.72 and 34.93 g during *kharif* 2015, *kharif* 2016 and pooled over years, respectively. Relatively the lowest seed yield per plant (11.83, 14.67 and 13.25 g) was noted in water soaked seeds space planted at 45 cm x 30 cm (S_1T_{10}) during both the years of experimentation as well as in pooled analysis (Table 11). The highest seed yield per plant was recorded by the combination of wider spacing and growth regulator GA_3 may be attributed to greater availability of nutrients, moisture and photosynthesis leading to better vegetative growth increased number of flowers, fruits and seed set with proper size and shape of seed. Singh[36] reported that the interaction combination GA_3 150 ppm with wider spacing (60 cm x 45 cm) gave maximum seed yield per plant.

Plant spacing of 45 cm x 30 cm and seeds treated with GA_3 150 ppm (S_1T_3) registered comparatively the minimum days to flower initiation (37.00 and 37.17 days) during *kharif* 2016 and pooled over years, while plant spacing of 60 cm x 30 cm and seeds treated with GA_3 150 ppm (S_2T_3) registered comparatively the minimum days to flower initiation (37.18 days) during *kharif* 2015 (Table 6). All the treatment combinations of different plant spacing with GA_3 at different concentrations were noted early days to flower initiation in comparison to other treatment combinations during both the years of experimentation and pooled over years. Plant spacing of 60 cm x 45 cm and seeds treated with NAA 50 ppm (S_3T_7) registered comparatively the maximum days to flower initiation (44.67 and 44.00 days) during *kharif* 2015 and pooled over years, while plant spacing of 60 cm x 30 cm and water soaked treatment (control) (S_2T_{10}) registered comparatively the maximum days to flower initiation (44.67 days) during *kharif* 2016. Similar results for days to flower initiation were reported by Singh[36] in okra.

Plant spacing of 60 cm x 45 cm and seeds treated with GA_3 150 ppm (S_3T_3) produced relatively the highest number of fruits per plant (9.03, 9.22 and 9.12) and number of seeds per fruit (74.44, 72.06 and 73.25) during both the years of experiment (*kharif* 2015 and 2016) as well as in pooled data, while relatively the lowest number of fruits per plant (5.36, 5.33 and 5.35) and number of seeds per fruit (43.28, 39.15 and 41.22) was recorded by plant spaced at 45 cm x 30 with water soaked seeds (S_1T_{10}) during both the years of experimentation and pooled over years (Table 7 and 10). Plant spacing of 60 cm x 45 cm and seeds treated with GA_3 150 ppm (S_3T_3) recorded significantly the highest fruit length (21.30 and 20.12 cm) and fruit thickness (2.18 and 2.23 cm) during both the years of experimentations. In pooled analysis, plants spaced with 60 cm x 45 cm and seeds treated with GA_3 150 ppm (S_3T_3) recorded comparatively the highest fruit length (20.71 cm) and fruit thickness (2.21 cm). Plant spacing of 45 cm x 30 cm and water soaked seeds (S_1T_{10}) noted significantly the lowest fruit length (12.85 and 13.87 cm) and fruit thickness (1.48 and 1.46 cm) during both the years of experiment (*kharif* 2015 and 2016), while the same treatment combination noted relatively the lowest fruit length (13.21 cm) and fruit thickness (1.47) in pooled data (Table 8 and 9). Similar results for all these traits were reported by Singh[36] in okra.

Table 1: Analysis of variance for experimental design (SPD) for plant growth parameters, seed yield per plant and its attributes in okra during *kharif* 2015 and 2016

Source of variation	Df	Field Emergence (%)	Plant Height (cm)	Stem Diameter (cm)	Number Of Branches Per Plant	Days to flower initiation	Number of fruits per Plant	Fruit length (cm)	Fruit thickness (cm)	Number of seeds per fruit	Seed yield per plant (g)
***Kharif* 2015**											
Spacing (S)	2	17.49	431.19 *	0.63 *	2.06 **	17.03	10.99 **	286.76 **	0.67**	751.17**	895.04 **
Error (A)	4	3.41	35.07	0.04	0.06	5.29	0.58	1.42	0.01	22.98	6.66
Treatments (T)	9	48.18 **	420.67 **	0.17 **	2.38 **	38.66**	4.06 **	5.26 **	0.09**	299.03**	224.21 **
S × T	18	9.50 **	18.28	0.03	0.10 *	1.88	0.22	2.93 **	0.01**	7.31	8.86
Error (B)	54	3.41	30.95	0.03	0.05	1.33	0.49	1.00	0.005	11.50	5.93
***Kharif* 2016**											
Spacing (S)	2	8.61	612.90 *	0.37 *	3.04 **	6.79	8.00 *	77.46 **	0.62**	701.03**	640.00 **
Error (A)	4	3.37	34.17	0.02	0.17	3.69	1.15	1.07	0.012	30.92	16.41
Treatments (T)	9	37.04 **	368.20 **	0.09 **	1.32 **	42.20**	4.51 **	3.74 **	0.08**	228.22**	186.10 **
S × T	18	7.96	23.39	0.01	0.08	0.64	0.23	1.16 *	0.01**	13.05	9.92
Error (B)	54	4.58	13.40	0.01	0.13	3.62	0.40	0.57	0.002	18.67	11.70
Pooled											
Year (Y)	1	3.22	45.31	1.65 **	5.01 **	8.73	0.01	5.05	0.001	0.79	16.69
Spacing (S)	2	21.50 *	1031.86 **	0.98 **	5.06 **	22.28 *	18.73 **	324.64	1.29**	1445.31**	1524.28 **
Y x S	2	4.60	12.23	0.02	0.05	1.54	0.26	39.58 **	0.002	6.89	10.76
Error (a)	8	3.39	34.62	0.04	0.11	4.49	0.86	1.24	0.01	26.95	11.54
Treatments (T)	9	81.74 **	718.60 **	0.23 **	3.38 **	78.65**	8.21 **	8.22 **	0.16**	517.25**	404.50 **
Y x T	9	3.48	70.28 **	0.03	0.32 **	2.21	0.36	0.78	0.01**	10.00	5.81
S x T	18	16.15 **	26.42	0.02	0.11	1.02	0.28	2.09	0.02	10.18	14.81
Y x S x T	18	1.31	15.25	0.02	0.08	1.50	0.17	2.00 **	0.01**	10.18	3.96
Error (b)	108	4.00	22.17	0.02	0.09	2.48	0.45	0.78	0.003	15.09	8.81

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

Table 2: Effect of plant spacing and seed treatments with growth regulators on field emergence (%) of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	97.22	96.29	95.83	96.45	96.53	94.44	94.44	95.14	96.88	95.37	95.14	95.79
T_2	97.22	96.29	97.22	96.91	97.92	95.37	98.61	97.30	97.57	95.83	97.92	97.11
T_3	98.61	99.07	98.61	98.77	99.31	98.15	100.00	99.15	98.96	98.61	99.31	98.96
T_4	95.83	95.37	93.05	94.75	96.53	95.37	91.66	94.52	96.18	95.37	92.36	94.63
T_5	96.53	98.15	93.05	95.91	97.22	97.22	93.05	95.83	96.88	97.68	93.05	95.87
T_6	97.92	98.15	91.64	96.21	98.61	98.38	94.42	97.14	98.27	98.73	93.03	96.67
T_7	95.10	94.44	93.03	94.19	93.72	94.44	93.09	93.75	94.41	94.44	93.06	93.97
T_8	94.44	95.60	93.05	94.36	95.14	94.44	94.44	94.67	94.79	95.02	93.75	94.52
T_9	89.58	90.73	91.66	90.66	91.67	92.59	93.61	92.62	90.62	91.66	92.63	91.64
T_{10}	90.97	91.66	95.00	92.54	92.36	92.59	95.00	93.31	91.67	92.12	95.00	92.93
Mean	95.34	95.67	94.21	95.07	95.90	95.30	94.83	95.37	95.62	95.48	94.52	95.21
Treatment effect	**S. Em ±**	**CD at 5 %**	**C. V. %**		**S. Em ±**	**CD at 5 %**	**C. V. %**		**S. Em ±**	**CD at 5 %**	**C. V. %**	
Spacing (S)	0.34	NS	1.94		0.34	NS	1.93		0.24	0.78	1.93	
Treatments (T)	0.62	1.75	1.94		0.71	2.02	2.25		0.47	1.32	2.10	
Interaction effect												
S x T	1.07	3.02	1.94		1.24	NS	2.25		0.82	2.29	2.10	
Y x S									0.34	NS	1.93	
Y x T									0.67	NS	2.10	
Y x S x T									1.15	NS		

Table 3: Effect of plant spacing and seed treatments with growth regulators on plant height (cm) of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	52.33	64.24	65.20	60.59	58.60	65.73	70.33	64.89	55.47	64.99	67.77	62.74
T_2	63.87	66.27	67.30	65.81	64.27	64.60	66.00	64.96	64.07	65.44	66.65	65.38
T_3	66.80	72.30	75.25	71.45	62.67	65.27	75.00	67.64	64.73	68.78	75.13	69.55
T_4	63.51	63.51	71.90	66.30	58.87	65.80	69.47	64.71	61.19	64.65	70.68	65.51
T_5	55.26	56.70	61.23	57.73	54.60	62.60	63.87	60.36	54.93	59.65	62.55	59.04
T_6	54.33	51.43	58.69	54.82	48.47	51.20	59.67	53.11	51.40	51.32	59.18	53.97
T_7	58.03	60.29	61.67	60.00	57.13	58.07	59.93	58.38	57.58	59.18	60.80	59.19
T_8	52.80	61.40	64.17	59.46	56.47	58.73	72.47	62.56	54.63	60.07	68.32	61.01
T_9	62.57	66.87	70.40	66.61	52.33	59.13	59.67	57.04	57.45	63.00	65.03	61.83
T_{10}	42.00	49.77	51.40	47.72	44.00	45.33	51.13	46.82	43.00	47.55	51.27	47.27
Mean	57.15	61.28	64.72	61.05	55.74	59.65	64.75	60.05	56.45	60.46	64.74	60.55
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	1.08	4.25	9.70		1.07	4.19	9.74		0.76	2.48	9.72	
Treatments (T)	1.85	5.26	9.11		1.22	3.46	6.10		1.98	6.32	7.78	
Interaction effect												
S x T	3.21	NS	9.11		2.11	NS	6.10		1.92	NS	7.78	
Y x S									1.07	NS	9.72	
Y x T									1.57	4.40	7.78	
Y x S x T									2.72	NS		

Table 4: Effect of plant spacing and seed treatments with growth regulators on stem diameter (cm) of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
T_1	1.45	1.78	1.84	1.69	1.41	1.71	1.78	1.63	1.43	1.75	1.81	1.66
T_2	1.69	1.60	1.87	1.72	1.42	1.62	1.72	1.59	1.55	1.61	1.80	1.65
T_3	1.79	1.96	2.19	1.98	1.58	1.59	1.83	1.66	1.68	1.78	2.01	1.82
T_4	1.49	1.88	2.01	1.79	1.35	1.50	1.67	1.51	1.42	1.69	1.84	1.65
T_5	1.48	1.66	1.96	1.70	1.38	1.49	1.56	1.48	1.43	1.58	1.76	1.59
T_6	1.58	1.65	1.69	1.64	1.33	1.37	1.59	1.43	1.46	1.51	1.64	1.54
T_7	1.61	1.66	1.67	1.65	1.37	1.45	1.51	1.44	1.49	1.56	1.59	1.55
T_8	1.44	1.60	1.65	1.56	1.35	1.38	1.51	1.42	1.40	1.49	1.58	1.49
T_9	1.59	1.64	1.82	1.68	1.39	1.47	1.53	1.46	1.49	1.55	1.68	1.57
T_{10}	1.31	1.48	1.61	1.47	1.30	1.34	1.40	1.35	1.31	1.41	1.51	1.41
Mean	1.54	1.69	1.83	1.69	1.39	1.49	1.61	1.50	1.47	1.59	1.72	1.59
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.04	0.14	11.43		0.03	0.11	10.48		0.03	0.08	12.33	
Treatments (T)	0.06	0.16	9.91		0.03	0.09	6.36		0.03	0.09	8.55	
Interaction effect												
S x T	0.10	NS	9.91		0.05	NS	6.36		0.06	NS	8.55	
Y x S									0.04	NS	12.33	
Y x T									0.05	NS	8.55	
Y x S x T									0.08	0.21		

Table 5: Effect of plant spacing and seed treatments with growth regulators on number of branches per plant of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	1.53	1.80	2.07	1.80	1.87	2.67	2.67	2.40	1.70	2.23	2.37	2.10
T_2	1.80	2.23	2.53	2.19	2.20	2.27	2.87	2.44	2.00	2.25	2.70	2.32
T_3	2.53	2.60	3.67	2.93	2.53	2.67	3.07	2.76	2.53	2.63	3.37	2.84
T_4	1.47	1.83	2.27	1.86	1.60	2.00	2.50	2.03	1.53	1.92	2.39	1.95
T_5	1.37	1.74	1.92	1.68	1.80	2.20	2.60	2.20	1.58	1.97	2.26	1.94
T_6	1.72	1.87	1.91	1.83	1.73	1.93	2.63	2.10	1.73	1.90	2.27	1.97
T_7	1.67	1.73	1.89	1.76	2.07	2.40	2.53	2.33	1.87	2.07	2.21	2.05
T_8	1.90	2.17	2.27	2.11	1.80	2.27	2.53	2.20	1.85	2.22	2.40	2.16
T_9	1.17	1.60	1.63	1.47	2.00	2.20	2.27	2.16	1.58	1.90	1.95	1.81
T_{10}	0.80	0.97	1.03	0.93	1.13	1.27	1.43	1.28	0.97	1.12	1.23	1.11
Mean	1.60	1.85	2.12	1.86	1.87	2.19	2.51	2.19	1.73	2.02	2.32	2.02
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.04	0.17	12.67		0.07	0.29	18.59		0.04	0.14	16.43	
Treatments (T)	0.07	0.20	11.56		0.12	0.34	16.62		0.13	0.43	14.70	
Interaction effect												
S x T	0.12	0.35	11.56		0.21	NS	16.62		0.12	NS	14.70	
Y x S									0.06	NS	16.43	
Y x T									0.10	0.28	14.70	
Y x S x T									0.17	NS		

Table 6: Effect of plant spacing and seed treatments with growth regulators on days to flower initiation of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	38.00	39.67	39.67	39.11	38.00	38.00	38.67	38.22	38.00	38.83	39.17	38.67
T_2	39.00	39.33	38.33	38.89	38.00	37.67	38.64	38.10	38.50	38.50	38.49	38.50
T_3	37.33	37.18	38.33	37.61	37.00	37.67	38.00	37.56	37.17	37.42	38.17	37.59
T_4	39.33	41.00	42.67	41.00	40.00	40.67	41.41	40.69	39.67	40.83	42.04	40.85
T_5	39.00	39.67	42.33	40.33	40.67	40.67	40.74	40.69	39.83	40.17	41.54	40.51
T_6	40.67	41.00	42.00	41.22	39.67	40.00	40.33	40.00	40.17	40.50	41.17	40.61
T_7	42.33	43.00	44.67	43.33	41.33	42.67	43.33	42.44	41.83	42.83	44.00	42.89
T_8	42.33	43.93	44.00	43.42	42.33	42.67	42.67	42.56	42.33	43.30	43.33	42.99
T_9	43.00	42.00	44.00	43.00	42.00	42.33	42.33	42.22	42.50	42.17	43.17	42.61
T_{10}	43.00	42.67	42.89	42.85	42.33	44.67	44.67	43.89	42.67	43.67	43.78	43.37
Mean	40.40	40.94	41.89	41.08	40.13	40.70	41.08	40.64	40.27	40.82	41.48	40.86
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.42	NS	5.60		0.35	NS	4.73		0.27	0.89	5.19	
Treatments (T)	0.38	1.09	2.81		0.63	1.80	4.68		0.37	1.04	3.85	
Interaction effect												
S x T	0.37	NS	2.81		1.10	NS	4.68		0.64	NS	3.85	
Y x S									0.39	NS	5.19	
Y x T									0.52	NS	3.85	
Y x S x T									0.914	NS		

Table 7: Effect of plant spacing and seed treatments with growth regulators on number of fruits per plant of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	5.90	6.33	6.67	6.30	6.37	6.50	7.10	6.66	6.13	6.42	6.88	6.48
T_2	6.67	6.90	7.23	6.93	6.60	6.80	7.52	6.97	6.63	6.85	7.38	6.95
T_3	7.53	8.40	9.03	8.32	7.53	8.25	9.22	8.34	7.53	8.33	9.12	8.33
T_4	6.33	6.47	7.80	6.87	6.60	6.20	6.55	6.45	6.47	6.33	7.18	6.66
T_5	6.80	7.33	7.90	7.34	6.90	7.40	7.50	7.27	6.85	7.37	7.70	7.31
T_6	6.43	7.80	8.10	7.44	7.20	7.63	8.30	7.71	6.82	7.72	8.20	7.58
T_7	6.77	7.23	7.57	7.19	6.10	6.80	7.45	6.78	6.43	7.02	7.51	6.99
T_8	6.54	7.47	7.93	7.31	6.43	7.13	7.53	7.03	6.49	7.30	7.73	7.17
T_9	6.43	7.67	8.13	7.41	7.00	7.70	8.50	7.73	6.72	7.68	8.32	7.57
T_{10}	5.36	5.75	6.49	5.87	5.33	5.67	6.67	5.89	5.35	5.71	6.58	5.88
Mean	6.48	7.14	7.69	7.10	6.61	7.01	7.63	7.08	6.54	7.07	7.66	7.09
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.14	0.54	10.70		0.20	0.57	15.12		0.12	0.39	13.10	
Treatments (T)	0.23	0.66	9.88		0.21	0.60	8.94		0.16	0.44	9.42	
Interaction effect												
S x T	0.40	NS	9.88		0.37	NS	8.94		0.27	NS	9.42	
Y x S									0.17	NS	13.10	
Y x T									0.22	NS	9.42	
Y x S x T									0.39	NS		

Table 8: Effect of plant spacing and seed treatments with growth regulators on fruit length (cm) of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	12.51	15.36	17.92	15.26	15.71	15.94	18.13	16.59	14.11	15.65	18.03	15.93
T_2	12.69	17.16	20.67	17.05	15.12	15.75	19.75	16.87	13.90	16.46	20.21	16.96
T_3	14.88	17.07	21.30	17.54	16.40	16.80	20.12	17.77	15.64	16.94	20.71	17.66
T_4	13.53	17.26	17.45	16.08	14.08	15.71	18.38	16.06	13.80	16.49	17.92	16.07
T_5	11.44	16.55	20.48	16.16	15.10	15.68	18.35	16.38	13.27	16.11	19.42	16.27
T_6	13.17	16.18	19.62	16.32	16.31	16.13	18.12	16.85	14.74	16.16	18.87	16.59
T_7	14.00	15.77	18.88	16.22	15.22	15.20	18.46	16.29	14.61	15.48	18.67	16.25
T_8	13.66	15.21	20.05	16.31	16.20	15.90	17.51	16.54	14.93	15.56	18.78	16.42
T_9	14.00	15.52	20.11	16.54	15.80	16.86	18.45	17.03	14.90	16.19	19.28	16.79
T_{10}	12.55	14.41	17.71	14.89	13.87	15.42	16.71	15.33	13.21	14.92	17.21	15.11
Mean	13.24	16.05	19.42	16.24	15.38	15.94	18.40	16.57	14.31	15.99	18.91	16.40
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.22	0.85	7.34		0.19	0.74	6.23		0.81	NS	6.80	
Treatments (T)	0.33	0.94	6.15		0.25	0.71	4.57		0.21	0.59	5.40	
Interaction effect												
S x T	0.58	1.63	6.15		0.44	1.24	4.57		0.58	NS	5.40	
Y x S									0.20	0.66	6.80	
Y x T									0.30	NS	5.40	
Y x S x T									0.51	1.43		

Table 9: Effect of plant spacing and seed treatments with growth regulators on fruit thickness (cm) of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	1.56	1.64	1.89	1.70	1.56	1.67	1.71	1.65	1.56	1.65	1.80	1.67
T_2	1.53	1.72	1.96	1.74	1.56	1.73	1.76	1.68	1.54	1.73	1.86	1.71
T_3	1.64	1.90	2.18	1.91	1.68	1.89	2.23	1.94	1.66	1.90	2.21	1.92
T_4	1.58	1.68	1.79	1.68	1.59	1.64	1.78	1.67	1.59	1.66	1.79	1.68
T_5	1.63	1.70	1.85	1.73	1.54	1.64	1.85	1.68	1.59	1.67	1.85	1.70
T_6	1.60	1.81	1.95	1.79	1.60	1.84	1.94	1.79	1.60	1.83	1.95	1.79
T_7	1.52	1.57	1.64	1.58	1.53	1.65	1.84	1.68	1.53	1.61	1.74	1.63
T_8	1.52	1.66	1.78	1.65	1.56	1.70	1.80	1.69	1.54	1.68	1.79	1.67
T_9	1.58	1.68	1.94	1.73	1.59	1.74	1.86	1.73	1.59	1.71	1.90	1.73
T_{10}	1.48	1.54	1.63	1.55	1.46	1.57	1.76	1.60	1.47	1.56	1.70	1.57
Mean	1.56	1.69	1.86	1.70	1.57	1.71	1.85	1.71	1.57	1.70	1.86	1.71
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.02	0.06	5.11		0.02	0.08	6.28		0.01	0.02	5.73	
Treatments (T)	0.02	0.07	4.12		0.02	0.05	3.16		0.02	0.08	3.67	
Interaction effect												
S x T	0.04	0.12	4.12		0.03	0.09	3.16		0.04	NS	3.67	
Y x S									0.02	NS	5.73	
Y x T									0.02	0.06	3.67	
Y x S x T									0.04	0.10		

Table 10: Effect of plant spacing and seed treatments with growth regulators on number of seeds per fruit of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	53.42	56.14	61.45	57.00	52.46	60.38	62.92	58.59	52.94	58.26	62.18	57.79
T_2	55.21	60.43	63.65	59.76	54.82	61.32	65.68	60.61	55.01	60.87	64.66	60.18
T_3	59.44	66.32	74.44	66.73	56.63	64.82	72.06	64.50	58.04	65.57	73.25	65.62
T_4	53.16	57.43	62.63	57.74	57.04	58.78	60.56	58.79	55.10	58.10	61.60	58.27
T_5	54.23	60.00	63.99	59.41	55.30	58.82	66.06	60.06	54.77	59.41	65.03	59.73
T_6	57.67	64.81	69.17	63.88	55.48	62.38	67.17	61.68	56.58	63.59	68.17	62.78
T_7	51.36	54.85	62.78	56.33	53.32	57.50	61.30	57.37	52.34	56.17	62.04	56.85
T_8	53.63	56.84	64.79	58.42	55.63	57.62	61.47	58.24	54.63	57.23	63.13	58.33
T_9	57.87	61.70	68.32	62.63	56.01	63.08	62.50	60.53	56.94	62.39	65.41	61.58
T_{10}	43.28	44.57	47.88	45.24	39.15	44.67	52.60	45.47	41.22	44.62	50.24	45.36
Mean	53.93	58.31	63.91	58.72	53.58	58.93	63.23	58.58	53.76	58.62	63.57	58.65
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.88	3.44	8.16		1.02	3.99	9.49		0.67	2.19	8.85	
Treatments (T)	1.13	3.21	5.78		1.44	4.08	7.38		0.92	2.57	6.62	
Interaction effect												
S x T	1.96	NS	5.78		2.49	NS	7.38		1.59	NS	6.62	
Y x S									0.95	NS	8.85	
Y x T									1.59	NS		
Y x S x T									2.24	NS	6.62	

Table 11: Effect of plant spacing and seed treatments with growth regulators on seed yield per plant (g) of okra during *kharif* 2015 and 2016

Treatments /Year	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Pooled
T_1	16.87	20.81	24.74	20.81	18.81	22.01	26.00	22.27	17.84	21.41	25.37	21.54
T_2	20.28	23.14	27.82	23.74	20.70	24.47	29.70	24.95	20.49	23.80	28.76	24.35
T_3	25.83	32.80	40.67	33.10	25.48	32.86	42.00	33.44	25.65	32.83	41.33	33.27
T_4	17.09	21.98	28.89	22.65	20.08	21.73	23.83	21.88	18.59	21.86	26.36	22.27
T_5	20.45	26.32	32.19	26.32	21.80	26.49	30.99	26.43	21.12	26.40	31.59	26.37
T_6	20.63	30.46	35.73	28.94	23.35	29.06	35.86	29.42	21.99	29.76	35.80	29.18
T_7	18.69	22.36	28.23	23.09	18.63	22.58	26.98	22.73	18.66	22.47	27.60	22.91
T_8	19.33	24.48	30.55	24.78	20.57	24.12	27.95	24.21	19.95	24.30	29.25	24.50
T_9	21.18	27.47	35.15	27.93	22.95	29.75	34.72	29.14	22.06	28.61	34.93	28.54
T_{10}	11.83	14.85	17.44	14.71	14.67	17.07	21.31	17.68	13.25	15.96	19.37	16.19
Mean	19.22	24.47	30.14	24.61	20.70	25.01	29.93	25.21	19.96	24.74	30.04	24.91
Treatment effect	S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %		S. Em ±	CD at 5 %	C. V. %	
Spacing (S)	0.47	1.85	10.49		0.74	2.90	16.06		0.44	1.43	13.63	
Treatments (T)	0.81	2.30	9.89		1.14	3.23	13.56		0.70	1.96	11.92	
Interaction effect												
S x T	1.41	NS	9.89		1.97	NS	13.56		1.21	NS	11.92	
Y x S									0.62	NS	13.63	
Y x T									0.99	NS	11.92	
Y x S x T									1.71	NS		

CONCLUSION

From the overall results obtained from the present investigation, it can be concluded that wider spacing S_3 (60 × 45 cm) was found effective in improving plant growth parameters, seed yield and its attributes of okra. The maximum improvement was observed in vegetative growth of plant, seed yield and yield attributing parameters by the application of growth regulator GA_3 150 ppm. A combination of wider plant spacing 60 x 45 cm and seed treatment of GA_3 @ 150 ppm before sowing for 8 hours was found the best suited, as it had good field emergence and produced the maximum plant height, stem diameter, number of branches per plant, number of fruits per plant, fruit length, fruit thickness, number of seeds per fruit and seed yield per plant. Therefore, it is advantageous to grow the okra crop after giving 8 hours seed treatment of GA_3 150 ppm with a plant spacing of 60 x 45 cm for getting high and quality seed production.

REFERENCES

1. Anonymous, Horticultural Statistics at a Glance 2015. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. 437 p.(2015a).
2. Anonymous. http://www.iasri.res.in/agridata/15data/chapter8/db2015tb8_7. pdf (2015b).
3. Ayyub, C.M., Manan, A., Pervez, M.A., Ashraf, M.I., Afzal, M., Ahmed, S., Rehman, S.U., Jahangir, M.M., Anwar, N. and Shaheen, M.R. Foliar feeding with gibberellic acid (GA_3): A strategy for enhanced growth and yield of okra (*Abelmoschus esculentus L.* Moench.). *African J. Agril. Res.,* **8(25):** 3299-3302 (2013).
4. Bhagure, Y.L. and Tambe, T.B., Effect of seed soaking and foliar sprays of plant growth regulators on germination, growth and yield of okra [*Abelmoschus esculentus* (L.) Moench] var. Parbhani Kranti. *The Asian J. Hort.,* **8(2):** 399-402 (2013).
5. Das, B.C. and Das, T.K., Efficacy of GA_3, NAA and Ethrel on seed expression in pumpkin (*Cucurbita moschata* Poir.) cv. Guamala Local. *Orissa J. Hort.,* **23:** 87-91 (1995).
6. Desai, K.D., Effect of spacing and growth retardant methods on growth yield and quality of okra [*Abmelmoschus esculentus* (L.) Moench] cv. GO 2. Ph. D. Thesis (Unpublished) Submitted to Navsari Agricultural University, Navsari (2011).
7. Dhage, A.A., Nagre, P.K., Bhangre, K.K. and Pappu, A.K., Effect of plant growth regulators on growth and yield parameters of okra. *The Asian J. Hort.,* **6(1):** 170-172 (2011).
8. Dwivedi, A., Dwivedi, S. and Balakrishnan, B.R., Effect of gibberellic acid on phonological behavior of *Abelmoschus moschatus* Medik. *Asian J. Med. Pharm. Res.* **3(2):** 60-65 (2013).
9. El-Waraky, Y.B., Effect of sowing date, plant density and phosphorus fertilization on seed yield of okra. *Alex. J. Agric. Res.,* **59(1):** 27-41 (2014).
10. Feleafel, M.N. and Ghoneim, I.M., Effect of plant density and nitrogen fertilizer on vegetative growth, seed yield and quality of okra plants**.** *J. Agric. Env. Sci. Alex. Univ.,* **4(2):** 24-36 (2005).
11. Ferres, H.M., The effect of maleic hydrazide in delaying flowering and fruiting. *Annual Report Agril. Biol. Abstr.,* **27(2):** 2243 (1951).
12. Kumar, A. and Purohit, S.S., *Plant Physiology: Fundamentals and Applications*. Agro Botanical Publishers, India (1986).
13. Kumar, S., Singh, P., Katiyar, R.P., Vaish, C.P. and Khan, A.A., Beneficial effect of some plant growth regulators on aged seeds of okra [*Abelmoschus esculentus* (L.) Moench] under field conditions. *Seed Res.,* **24(1):** 11-14 (1996).
14. Kumar, V., Dhankhar, S.K., Chandanshive, A.V. and Yadav, N., Effect of spacing on growth and yield parameters of two varieties of okra, *Abelmoschus*

esculantus (L) Moench. *Int. J. Farm Sci.*, **6(1):** 163-168 (2016).

15. Madisa, M.E., Mathowa, T., Mpofu, C. and Oganne, T.A., Effects of plant spacing on the growth, yield and yield components of okra *(Abelmoschus esculentus L.)* in Botswana. *American J. Exptl. Agric.*, ,**6(1):** 7-14 (2015).
16. Marie, A.I., Ihsan, A. and Salih, S.H., Effect of sowing date, topping and some growth regulators on growth, pod and seeds yield of okra *(Abelmoschus esculentus* L. Moench). *African Crop Sci. Conf. Proc.*, **8:** 473-478 (2007).
17. Maurya, R.P., Bailey, J.A. and Chandler, J.A., Impact of plant spacing and picking interval on the growth, fruit quality and yield of okra (*Abelmoschus esculentus* (L.) Moench). *American J. Agric. Forest.*, **1(4):** 48-54 (2013).
18. Mohammadi, G., Khah, E.M., Petropoulos, S.A., Chachalis, D.B., Akbari, F. and Yarsi, G., Effect of gibberellic acid and harvesting time on the seed quality of four okra cultivars. *J. Agril. Sci.*, **6(7):** 200-211 (2014).
19. Moniruzzaman, M., Uddin, M.Z. and Choudhury, A.K., Response of okra seed crop to sowing time and plant spacing in south eastern hilly region of Bangladesh. *Bangladesh J. Agril. Res.*, **32(3):** 393-402 (2007).
20. Muhammad, A., Muhammad, A.A. and Ahmed, A., Impact of phosphorus and planting geometry on growth, yield and quality of green pods in okra. *Int. J. Agric. Biol.*, **3(4):** 341-344 (2002).
21. Naylor, A.W. and Davis, E.A., Maleic hydrazide as a plant growth inhibitor. *Botanical Gazette*, **112(1):** 112-126 (1950).
22. Omran, A.F., EI-Bakry, A.M. and Gawish, R.A., Effect of soaking seeds in some growth regulators on growth, chemical constituents and yield of okra. *Seed Sci. Tech.*, **8:** 161-168 (1980).
23. Pandey, S.N. and Sinha, B.K., *Plant Physiology*. Vikas Publication House Pvt. Ltd., New Delhi. (1999).
24. Parmar, P.N., Bhanvadia, A.S. and Chaudhary, M.M., Effect of spacing and nitrogen levels on yield attributes, seed yield and economics of okra (*Abelmoschus esculentus* L. Moench) during *kharif* season under middle Gujarat conditions. *Trends Biosci.*, **8(8):** 2160-2163 (2015).
25. Patil, R.S., Chaitanya, H.S. and Nagesh, L., Effect of plant growth regulators and fruit picking on seed yield and seed quality attributes of okra in coastal Karnataka**.** *Environ. Ecol.*, **32(1A):** 215-219 (2014).
26. Patil, B.C., Ajjappalavara, P.S. and Dhotre, M., Effect of plant growth regulators on seed yield and quality of okra. *Proceedings of National Conference on Production of Quality Seeds and Planting Material: Health Management in Horticultural Crops*, March 11-14, 2010, New Delhi. pp. 114-116 (2010).
27. Patil, C.N., Mahorkar, V.K., Dod, V.N., Peshattiwar, P.D., Kayande, N.V. and Gomase, D.G., Effect of seed treatment with gibberellic acid and maleic hydrazide on growth, seed yield and quality of okra cv. Parbhani Kranti. *The Asian J. Hort.*, **3**(1): 74-78 (2008).
28. Patil, D.R. and Patel, M.N., Effect of seed treatment with GA_3 and NAA on growth and yield of okra [*Abmelmoschus esculentus* (L.) Moench] cv. GO-2. *Asian J. Hort.*, **5(2):** 269-272 (2010).
29. Patil, R.V., Kadam, K.G. and Kolase, S.K., Effect of plant growth regulators on seed yield and quality of okra (*Abelmoschus esculentus*). *Ecol., Environ. Conserv. Paper*, **13(4):** 841-842 (2007).
30. Philip**,** C.B., Sajo, A.A. and Futuless**,** K.N., Effect of spacing and NPK fertilizer on the yield and yield components of okra (*Abelmoschus esculentus* L.) in Mubi, Adamawa State, Nigeria. *J. Agron.*, **9:** 131-134 **(**2010).
31. Rani, M.U., Jyothi, K.U. and Kumar, M.K., Response of plant growth regulators and micronutrients on growth and yield of okra (*Abelmoschusesculentus* L. Moench) cv. Arka Anamika. *Bioinfolet - A*

Quarterly J. Life Sci., **10**(**3b):** 1079-1084 (2013).

32. Ravat, A.K. and Makani, N., Influence of plant growth regulators on growth, seed yield and seed quality in okra (*Abelmoschus esculentus* L. Moench) cv. GAO-5 under middle Gujarat condition. *Int. J. Agric. Sci.*, **11(1):** 151-157 (2015).
33. Sharma, V., Singh, V., Yadav, A.C. and Duhan, D., Quality seed production of okra in northern plains of India. *Veg. Sci*., **39(2):** 201-202 (2012).
34. Singh, J.P. and Kumar, S., Effect of plant geometry and nutrition on the phenological traits and chemical composition of pod of okra (*Abelmoschus esculentus* L.) cv. Pusa Sawani. *Int. J. Community Sci. Technol.*, **1(1):** 45-52 (2015).
35. Singh, R.K. and Singh, K.P., Effect of seed treatment with plant growth substance on germination, vegetative growth and yield of okra. *Proc. Bihar Aca. Agric. Sci.*, **25(2):** 24-27 (1977).
36. Singh, V., Effect of growth regulators and spacing on growth, seed yield and quality of okra (*Abelmoschuc esculentus* (L.) Moench). Ph. D. Thesis (Unpublished) Submitted to Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (2003).
37. Sircar, S.M., *Plant Hormone – Research in India*. Indian Council of Agricultural Research, New Delhi (1971).
38. Sonu Singh, J.P., Rajbeer Nathiram, and Kaushik, H., Effect of sowing dates and plant geometry on growth and yield of okra cv. Parbhai Kranti and Pus A-4. *Asian J. Hort*., **8(2):** 772-774 (2013).
39. Steel, R.G.D. and Torrie, J.H., *Principles and Procedures of Statistics*. 2nd Edition. McGraw-Hill, New York (1980).
40. Surendra, P., Nawalagatti, C.M., Chetti, M.B. and Hiremath, S.M., Effect of plant growth regulators and micronutrients on morpho-physiological and biochemical traits and yield in okra. *Karnataka J. Agric. Sci.*, **19**(3): 694-697 (2006).
41. Tindall, H.D., Vegetables in the Tropics. First Edition. MacMillian Press Ltd., London. pp: 328. **(**1986).