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Effect of planting density and gibberellic acid on growth and yield of okra (*Abelmoschus esculentus* L.)

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Abstract
In order to explore the possibility of improving growth and yield of okra an experiment entitled "Effect of planting density and Gibberellic acid on growth and Yield of okra (*Abelmoschus esculentus* L.)" have been conducted at the research farm of AKS University, Sherganj Satna. During kharif seasons of 2015-16. The experiment comprised three level of Gibberellic acid such as 0ppm, 10ppm, and 20ppm and three spacing's viz., 60 x 30cm, 60 x 45cm and 60 x 60cm. Experiment was laid out in RBD (with factorial concept) with three replications. The results of the experiment showed that application of Gibberellic acid (20ppm) had significant influence on most of the parameters such as; Plant height (cm), number of leaves per plant, number of branches per plant and phenological traits i.e. days taken to first flower initiation and yield parameters such as; fruit length (cm), fruit yield per plant (g), fruit yield per plot (kg). The spacing 60 x 45cm had significant influence on most of the parameters such as Plant height (cm), number of leaves per plant, number of branches per plant and phenological parameter i.e. days taken to first flower initiation, and yield parameters such fruit yield per plant (g) and fruit yield per plot (kg).

Keywords: Okra (*Abelmoschus esculentus* L.), planting density, gibberelic acid, growth and yield

Introduction
Okra (*Abelmoschus esculentus* L.) is one of the fast growing annual herb; and the tender fruits called capsules are used as a common vegetable. It is one of the important fruit vegetable of tropical and subtropical regions of the world. Its cultivation is also adopted in rainy season in most part of the world. (Thakur & Arora 1999) [6]. Okra popularly known as 'bhendi' is an indeterminate vegetable crop commercially cultivated in tropical and subtropical countries. It is specially valued for its tender and delicious fruits and has been reported to have an average nutritive value of 3.21 which is higher than tomato, egg plant and most of the cucurbits. Further bhendi has a vast a potential as one of the foreign exchange earning crops which accounts for about 60 percent of the export of fresh vegetables. Okra plants are grown commercially in many countries such as India, Japan, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Malaysia, Thailand, Brazil and in the Southern United States (Benjawan *et al*., 2007) [1]. Spacing is also considered on an important cultural operations governing yield of okra. Narrow spacing result in higher plant population lower's, higher competition for all the resource factor but in wider spacing this competition is less which result into healthier plants. Suitable plant spacing can lead to optimum yield but incorrect plant spacing could result in relatively low yield and poor quality fruits. A significant decrease of pod yield per plant with increasing plant density was observed by plant populations may result in rigorous growth, poor quality fruits and low yield due to intra specific competition. The effect of plant spacing on the growth and yield of okra have also been reported by many authors. (Maurya *et al*. 2013) [3] Gibberellins (GA3) are a family of plant hormones that have many responses in plants, through seed germination to senescence. The mainly generally available compound is GA3 or gibberellic acid, which tempts stem and inter node elongation, seed germination, enzyme production during germination and fruit setting and growth (Shrivastava *et al.* 1971) [5].

Materials and Methods: The details of materials used, experimental procedures followed and techniques adopted during the course of present investigation entitled "Effect of planting density and Gibberellic acid on growth and yield of okra" have been grown as various experiment site conducted at the farm of AKS University, Satna M.P. (80°21' to 81°23' east longitude and 23°58' to 25°12' north latitude). The experimental plot was located about 2000 meters East of AKS University, Campus. The experiment was laid out in factorial Randomized block design with 27 treatments and each treatment was replicated three and details of layout plan and treatments are given as follows. The present research was carried out at AKS University, Satna (M.P) by using okra crop. The experimental details such as "Factorial Randomized Block Design", Details of the treatments; Gibberellic acid dose - 0, 10 and 20 ppm (part per million)

G_0 = 0ppm (control)
G_1 = 10ppm
G_2 = 20ppm
Spacing - 60×30, 60×45 and 60×60 cm.
S_1 = 60×30 cm
S_2 = 60×45 cm
S_3 = 60×60 cm

Observations: (A). Growth Parameters: (i) Plant Height (cm): Plant height (cm) was measured on randomly selected five plants from inner nine observation plants. It was measured at 30 days interval starting from 30 days after seed sowing to till final harvesting.

(ii) Number of leaves per plants: The number of leaves was measured starting from 30 days after seed sowing to final harvesting.

(iii) Number of branches per plant: Primary branches were counted on randomly selected five plants from observation plants. It was measured at 30 days interval starting from 30 days after seed sowing to final harvesting.

(B) Phonological parameter: (i) Days taken to first flower initiation: Days to first flower of individual inner plants were observed after randomly selecting the plants. The average of five plants was considered as days to first flower.

(C) Yield Parameters: (i) Fruit yield per plant (kg): Picking of fresh marketable fruit was done from the observational plants separately throughout the harvesting period at an interval of 3days it was totaled and then average yield per plant was worked out for each plant.

(ii) Fruit yield per plot (kg): Yield per plot was calculated from yield of inner observational plants. The average yield per plant calculated as above was multiplied (the total plants accommodated in each sub-plot of 1.80 m2) gave the yield per plot.

Result: (A) Growth parameters: (i) Plant height at 30 DAS: (a) Effect of plant spacing's (cm): Use of spacing's caused beneficial response on plant height of okra and maximum plant height i.e. 29.21cm was obtained at 30 days after sowing when S_2 (60 x 45cm) plant spacing's (cm) was kept.

(b) Effect of gibberellic acid: Use of Gibberellic acid did not cause any effective effect on height of the plant and plant height was remained unaffected.

(ii) Plant height at 60 DAS: (a) Effect of plant spacing's (cm): Use of plant spacing's did not cause any response on height of the plant and plant height was remained unaffected.

(b) Effect of gibberellic acid: Plant height (cm) was affected by the use of Gibberellic acid in okra. Maximum height of plant i.e. (81.98cm) was recorded in G_2(20 ppm) followed by Gibberellic acid at 60day after sowing.

(iii) Plant height at harvest: (a) Effect of plant spacing's (cm): Use of spacing also caused beneficial effect on plant height of okra and maximum plant height i.e. (119.71 cm) at harvest. Was obtained when plant spacing's used 60 x 45cm.

(b) Effect of gibberellic acid: Plant height (cm) was affected by the use of Gibberellic acid in okra. Maximum height of plant i.e. (122.53 cm) was obtained when Gibberellic acid was applied @ 20ppm at harvest.

(iv) Number of leaves per plant: (a) Number of leaves per plant at 30DAS

(a) Effect of plant spacing's (cm): Use of spacing's caused beneficial response on number of leaves per plant in okra and large number of leaves i.e. (15.82) were recorded when plant spacing was kept 60 x 45cm.

(b) Effect of gibberellic acid: The different levels of gibberellic acid increased the number of leaves per plant during the growth period. In most case the highest number of leaves (16.69) was observed withG_2 (20ppm).

(v) Number of leaves per plant at 60DAS: (a) Effect of plant spacing's (cm): Use of spacing's caused beneficial response on number of leaves per plant in okra and large number of leaves (41.40) were recorded when plant spacing's (cm) was kept 60 x 45cm.

(b) Effect of gibberellic acid: The different levels of gibberellic acid increased the number of leaves per plant during the growth period. In most case the highest number of leaves (43.38) was observed withG_2 (20ppm).by the use of gibberellic acid at 60 day after sowing.

(vi) Number of leaves per plant at harvest: (a) Effect of plant spacing's (cm): The effect of plant spacing of 60 x 45 cm resulted in large number of leaves per plant. This result was significantly different from the number of leaves (96.18) at harvest.

(b) Effect of gibberellic acid: The different levels of gibberellic acid increase the number of leaves per plant in the highest number of leaves was observed with G_2 (20ppm) significantly increased the number of leaves per plant (102.82) at harvest.

(vii) Number of branch per plant: (ix) Number of branch per plant at 30DAS

(a) Effect of plant spacing's (cm): Use of plant spacing's (cm) did not cause any effective effect on branch of the plant and number of branch was remained unaffected.

(b) Effect of gibberellic acid: Use of Gibberellic acid was found to be effective in increasing number of branch per plant at 30 days after sowing and large number of

(viii) Number of branch per plant at 60DAS: (a) Effect of plant spacing's (cm): The effect of plant spacing of 60 x 45 cm resulted in large number of branch per plant. This result was significantly different from the number of branch (2.56) at 60 days after sowing.

(b) Effect of gibberellic acid: The number of branches per plant was recorded at 60 days after sowing the number of branches per plant varied significantly due to the different levels of Gibberellic acid. The highest number of branches per plant (2.91) was found with G_2 (20ppm) and shortest number of branches per plant (1.73) was found with G_0 (oppm).

(ix) Number of branch per plant at harvest: (a) Effect of plant spacing's (cm): Use of spacings also caused beneficial effect on number of branches per plant of okra. The maximum number of branches (4.73) at harvest obtained respectively plant spacing used 60 x 45 cm.

(b) Effect of gibberellic acid: The different levels of Gibberellic acid increase the number of branches per plant during the growth period. In most case the highest number of branch (4.99) was observed with G_2 (20ppm).

(x) Days taken to first flower initiation: (a) Effect of plant spacing's (cm): Use of spacing's caused beneficial response on days taken to first flower initiation of okra and minimum days taken to first flower initiation i.e. 38.67 days was obtained when S_2 (60 x 45cm) plant spacing and maximum days taken to first flower initiation i.e. 39.78 days was obtained when plant spacing was kept 60x60cm.

(b) Effect of gibberellic acid: Use of Gibberellic acid significantly affected the days taken to first flower initiation. The minimum days taken to first flower initiation (37.36 days) was noted under the Gibberellic acid G_2 (20ppm) and maximum days to first flower initiation (42.91 days) was noted under the Gibberellic acid G_0 (0ppm) successive in the Gibberellic acid levels significantly day taken to first flower initiation.

(xi) Fruit yield per plant (g): (a) Effect of plant spacing's(cm): Use of spacing's caused effective response on fruit yield per plant (g) of okra and maximum fruit yield per plant i.e. (320.51g) were obtained when S_2 (60 x 45 cm) plant spacing was kept.

(b) Effect of gibberellic acid: Use of Gibberellic acid significantly increased fruit yield per plant (g). The highest fruit yield per plant i.e. (339.47g) was obtained with G_2 (20ppm).

(xii) Fruit yield per plot (kg): (a) Effect of plant spacing's (cm): Result indicated that the effect of plant spacings (cm) significantly affected fruit yield per plot (3.71kg). The maximum fresh weight of pod was recorded when using 60x45 cm plant spacing's.

(b) Effect of gibberellic acid: The different level of Gibberellic acid increased the fruit yield per plot (kg) during the yield period. The highest fruit yield per plot (3.87kg) was obtained using 20ppm Gibberellic acid (in treatment G_2).

Discusson: Effect of Gibberellic acid: The increase of various level from 0, 10 and 20ppm of Gibberellic acid significantly increase the growth character like height of the plant, number of plant, number of leaves, number of branch. Maximum plant height (122.53cm) was noted on the highest level of Gibberellic acid (20ppm) and maximum number of leaves (102.82) per plant was observed under (20ppm) level of Gibberellic acid and maximum number of branches (4.99) was also observed with 20ppm Gibberellic acid. These findings are similar to (Malihe and Noori 2014). Physiological character viz., Days taken to first flower initiation, significantly varied due to different level of Gibberellic acid. fruit yield per plant (g), fruit yield per plot (kg). Were significantly affected by different level of Gibberellic acid. The better growth parameter might have been the reason for superior yield attribution trial in the plot receiving spraying with 20ppm Gibberellic acid.

Effect of plant spacing: Use of spacing also cause beneficial response on growth parameters such as plant height (cm), number of leaves per plant, number of branches per plant and phonological parameter is days taken to first flower initiation. Yield parameters such as fruit yield per plant (g) and fruit yield per plot (kg) of okra. The beneficial effect due to different plant spacing was significant with plant height, number of leaves per plant, number of branches per plant, days taken to first flower initiation, fruit yield per plant and fruit yield per plot. Spacing's S_2 (60 x 45 cm) significantly superior over all other spacing's with the minimum result is found in S3 (60 x 60 cm) in okra crop. Similar results were obtained by Yadav *et al*., (1999) [4] in okra crop.

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