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Effect of NAA, GA_3 on growth, yield and quality of cluster bean, okra and cowpea in arid condition of south-western Rajasthan

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Abstract

The field experiments were conducted on three different vegetable crops at College of Agriculture, Sumerpur (Rajasthan) during Kharif and Zaid season of 2018-19 continuously to study the effect of plant growth regulators (NAA, GA_3) on growth, yield and quality of cluster bean [*Cyamopsis tetragonoloba* (L) Taub.], okra (*Abelmoschus esculentus* L.) and cowpea (*Vigna unguiculata*). The experiments were laid out in randomized block design with sixteen treatments in three replications. The treatment comprised of three levels of individual growth regulator of GA_3 and NAA (50, 100, 200 ppm) and their nine combinations. Results revealed that the all variables regarding vegetative and reproductive growth were influenced by different concentrations of the growth regulators. Growth regulators were less effective when applied individually as compared to their combined use however, performance of plants treated with individual PGR was better than the untreated plants. In cluster bean, among the different combination of treatments, T_{12} (GA_3 100 ppm + NAA 200 ppm) registered the maximum number of pod cluster plant^{-1} (20.25), number of pods plant^{-1} (344.71), marketable green pod yield (116.07 q ha^{-1}), highest net return of Rs.265207.50 ha^{-1} with maximum B:C ratio of 3.23 as compared to rest of the treatment combinations. In okra T_{15} treatment (GA_3 200 ppm and NAA 200 ppm) performed better than other treatments with the highest number of fruits plant^{-1} (12.60), fruit length (10.90 cm), fresh weight of fruit (10.69 g), total fruit yield (67.34 q ha^{-1}) and net return of Rs. 132867.5 ha^{-1} with maximum B:C ratio of 2.74. Cowpea also performed better when medium dose of growth regulators (100 ppm GA_3 + 100 ppm NAA) were applied under T_{11} treatment with maximum pod yield plant^{-1} (198.85 g), marketable green pod yield (99.64 q ha^{-1}), highest net return Rs. 133394.00 ha^{-1} with maximum B:C ratio of 3.81 as compared to rest of the treatments.

Key words: GA_3, Napthalene-acetic-acid, morpho-physiological traits, plant growth regulator

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench], is an important herbaceous annual plant belongs to family Malvaceae growing in tropical and subtropical parts of the world. India is the global leader in the okra production (Saxena *et al*., 2016). These green fruits are rich sources of vitamins, calcium, potassium, magnesium, phosphorus, vitamin 'A' and 'C'. The edible fruit of okra (100 g) contains moisture (89.6%), vitamin A (88.01 I.U.), thiamine (0.07 mg), vitamin C (13 mg), riboflavin (0.1mg) with the little amount of iron (1.5 mg) and other nutrients. Okra is extensively grown in India throughout the year for its tender non-fibrous edible fruit. It is very popular among the farmers because of easy in growing and has wider adaptability range. Besides being a vegetable, it also has medicinal and industrial importance. Cluster bean [*Cyamopsis tetragonoloba* (L) Taub.] and Cowpea [*Vigna unguiculata* (L.) Walp.] belongs to the family leguminosae, both are one of the important summer vegetables. It can be grown on soil of low fertility as well as drought prone arid and semi arid area of Rajasthan. They are a good source of protein, vitamin A, thiamin, riboflavin, iron, phosphorus, and potassium, and a very good source for vitamin C, folate, magnesium, and manganese. These crops are gaining popularity among vegetable growers due to higher remuneration and steady market demand. A nitrogen-fixing legume, cluster bean and cowpea can be included in crop rotations to build up soil nitrogen. Cluster bean and cowpea is particularly useful for building up fertility in country that has been run down from over-cropping. Provided crop is properly nodulated, cluster bean and cowpea can fix 20 to 140 kg residual nitrogen ha^{-1} into the soil. This can give a significant bonus to later cereal crops in the rotation. However, poor productivity level with traditional practices impairs wider acceptability of the crop. In crop production plant growth regulators promotes growth along with the longitudinal area, increase number of branches, early flower initiation, fruit set, fruit quality and subsequently contributes towards higher production when applied at various concentrations. There is a tremendous scope to increase the current productivity level by adopting innovative practices. Plant growth regulators

(PGR's) are considered as a new generation of agrochemicals which affect the physiology of plant growth and influence the natural rhythm of a plant when added in small amounts. Different treatments of plant growth regulators were found effective in increasing the growth and yield parameters through enhanced biomass production and translocation of assimilates toward developing sink. In addition, GA_3 and NAA are also emerging as plant booster for improving the physiological efficiency of the crop. GA_3 has been reported beneficial in cluster bean, okra and cowpea because it is involved in the regulation of growth and development of the crop.

The role of GA_3 has been reported to be involved in regulation of growth through cell division and enlargement. NAA is also being used in many vegetable crops at various stages of development for increasing growth and yield by way of cell elongation, enlargement and differentiation. Artificial foliar spray of growth regulators has been found effective in increasing vegetative growth, early fruiting, total yield and quality of fruits in many vegetables (Ibrahim *et al.*, 2007). Plant growth regulators are one of the cheap and widely used physiological manipulators which can be used for productivity enhancement in okra. Although plant growth regulators have great potential for growth improvement but their application has to be planned sensibly in terms of optimal dose, stage of application, crop specificity and seasons (Khan *et al.*, 2006). Even the same growth regulator at different dose can bring about different results. To obtain the precise recommendations regarding growth regulators (GA_3 and NAA) application through foliar spray on cluster bean, okra and cowpea crop during kharif and zaid season, field experiments entitled with the objectives to assess response of foliar application of NAA and GA_3 on growth and yield of cluster bean, okra and cowpea and to evaluate the economic feasibility of the treatments.

Materials and Methods

The present experiments were carried out during kharif and zaid season of 2018-19 at the experimental field of College of Agriculture, Sumerpur (Rajasthan). The experiment was conducted on three different vegetable separately and laid out in randomized block design with three replications which have sixteen treatment combinations. The treatments comprised three levels of GA_3 [T_1 (50 ppm), T_2 (100 ppm) and T_3 (200 ppm)] and NAA [T_4 (50 ppm), T_5 (100 ppm) and T_6 (200 ppm)] and nine combinations of GA_3 and NAA [T_7- 50 ppm GA_3 + 50 ppm NAA, T_8- 50 ppm GA_3 + 100 ppm NAA, T_9- 50 ppm GA_3 + 200 ppm NAA, T_{10}- 100 ppm GA_3 + 50 ppm NAA, T_{11}- 100 ppm GA_3 + 100 ppm NAA, T_{12}- 100 ppm GA_3 + 200 ppm NAA, T_{13}- 200 ppm GA_3 + 50 ppm NAA, T_{14}- 200 ppm GA_3 + 100 ppm NAA, T_{15}- 200 ppm GA_3 + 200 ppm NAA)] with untreated [T_0 (distilled water)]. The soil of experimental field was uniform in fertility, sandy loam in texture, low in organic carbon (0.58% and 0.58%), medium in available P (25.5 kg and 24.5 kg ha^{-1}) and high in K (280.0 kg and 285.0 kg ha^{-1}) with saturated extraction electrical conductance of 2.0 $ds.m^{-1}$ and slightly alkaline reaction (pH 8.2) during both kharif and zaid season of experimentation, respectively. The abiotic factors *viz.*, average minimum and maximum temperatures were 28.0° ± 5.0°C and 38.0° ± 5.0°C, average relative humidity of 58.0 ± 10.0% and 485.0 mm rainfall per annum were recorded during the experimentation. The experiment field was supplied with well rotten farm yard manure (20 t ha^{-1}) as basal dose at 20 days before seed sowing. Fertilizers (NPK 60:40:40 kg ha^{-1} for okra, 30:40:40 kg ha^{-1} for cluster bean and cowpea) were supplied through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively. Basal application of full dose of SSP, MOP and half dose of urea was given at the time of sowing and remaining half dose of urea was given as top dressing at 30 days after sowing. Seeds of okra cv. 'Arka Anamika', clusterbean cv. 'Thar Bhadvi' and cowpea cv. 'Kashi Kanchan' were sown in month of February for zaid season crop and in July for kharif crop at the spacing of 45 cm x 45 cm with a net plot size of 6.0 m^2. NAA and GA_3 were applied at 4 true-leaf stage with two litre capacity hand sprayer. The crop was raised adopting standard cultural practices and plant protection measures were implemented uniformly in all treatments as and when required. For recording different field observations, five plants of cluster bean, okra and cowpea from each net plot area were selected randomly in the beginning and tagged with the labels.

The data on parameters like plant height at maturity (cm), number of leaves $plant^{-1}$, number of days taken to first flowering, number of pods/fruits $plant^{-1}$, fruit quality, yield (q ha^{-1}), net return (Rs) and B:C ratio were recorded. Chlorophyll content of leaves was observed by direct method used by SPAD. The number of cluster per plant was counted at the time of each picking and average was worked out. The number of pods/fruits were counted per cluster at each picking and then averaged to obtained number of pods per cluster. The number of pods/fruits per plant were counted at each picking and then averaged to obtained number of pods/fruits per plant. From the ten randomly selected pods/fruits, the lengths of pod/fruit was measured in centimeter from the stalk to the apex by thread and mean pod length was determined by summing up the length of all ten pods and divided by ten. Ten fresh and marketable pods/fruits from each treatment were selected randomly for weighing and their average value was recorded as pod/fruit weight in gram. Pod/fruit yield was derived by summing up the pod weight of all the pods/fruits harvested from the net plot during all the pickings and then summed to obtain the pod/fruit yield. The values of pod/fruit yield were converted in q ha^{-1}. Furthermore, the net return was calculated by subtracting cost of each treatment from gross return. The gross return was calculated from yield multiplied by average market rate during the period of investigation. The benefit cost ratio was calculated by dividing net return to total cost. The data were analyzed statistically following the standard procedure given by Panse and Sukhatme (1967). Significance of differences among treatment means were calculated at 5 per cent level of significance.

Results and Discussion

The results of the analysis of variance showed that the effects of growth regulators *i.e.* NAA and GA_3 on vegetative and yield parameters were significantly affected by treatments ($P \leq 0.05$) in these experiments (Table 1 to 6).

Effect of GA_3 and NAA on cluster bean

The application of both PGRs (GA_3 and NAA) either alone or in combination significantly improved growth and yield related traits of cluster bean. The maximum plant height (98.72 cm) and number of leaves plant^{-1} (99.0) were recorded in plants sprayed with solution containing both 50 ppm GA_3 + 200 ppm NAA (T_9 treatment), which was at par with all combined application of both growth regulators. It is clear from the study that exogenous application of plant growth regulators stimulate the effects of enzymatic activities of natural occurring hormones that accelerated and modified the growth and development of plants and hence increased number of leaves and plant height.

The results are in line with the findings of Patel *et al.* (2011) in cowpea, Satodiya *et al.* (2011) and Dholariya *et al.* (2018) in cluster bean. Days to first flower appearance is one of the important parameters attributing yield, treatment combination with NAA 200 ppm + GA_3 200 ppm (T_{15}) showed the earliest (35.20 days) flower appearance followed by 200 ppm GA_3 + 50 ppm NAA (T_{13}) (35.40 days), whereas the control (44.67 days) was latest for appearance of flowering (Table 1). This might be due to the reason that higher concentration of GA_3 reduced the days required for flowering which ultimately led towards early flower production. These results were supported by Bhagure and Tambe (2013) and Meena *et al.* (2017) in okra. Plant growth regulators were found to have non-significant effect on chlorophyll content of leaves (SPAD value), number of pods cluster^{-1}, pod length and fresh weight of pods. The observation recorded on yield attributes (Table 1 and 2) indicated that all the treatments significantly enhanced the yield parameters as compared to control. The highest number of cluster plant^{-1} (20.25), maximum number of pods plant^{-1} (344.71) and marketable green pod yield (116.07 q ha^{-1}) were recorded when GA_3 100 ppm + NAA 200 ppm (T_{12} treatment) was sprayed to the plants. This might be due to synergistic effect of GA_3 in stimulation of cell division and cell elongation, which ultimately affect overall growth and yield of the plant. Similar results were also recorded by Dholariya *et al.* (2018) in cluster bean. Pod quality was also significantly influenced by applications of growth regulators and the highest quality score (8.44) observed by the combined application of both regulators with 100 ppm GA_3 + 200 ppm NAA (T_{12} treatment).

The results are in conformity with Golakiya *et al.* (2017) in cowpea, Patel *et al.* (2015), Dholariya *et al.* (2018) in cluster bean. The data presented in Table 2 revealed that among the different combination of treatments, T_{12} (GA_3 100 ppm + NAA 200 ppm) registered the highest net return Rs. 265207.5 ha^{-1} with maximum B:C ratio value of 3.23:1 as compared to rest of the treatment combinations. Moreover, the next best treatment was T_{11} (GA_3 100 ppm + NAA 100 ppm) registered the net return of Rs. 252771.7 ha^{-1} with B:C ratio of 3.08:1. Whereas, treatment T_0 (Control) recorded the lowest net return of Rs. 168434 ha^{-1} with lowest B:C ratio of 2.05:1. This might be due to higher green pod yield registered under T_{12} treatment. Similar result was also found by Golakiya *et al.* (2017) in cowpea and Dholariya *et al.* (2018) in cluster bean.

Effect of GA_3 and NAA on okra

The plant height recorded at 60 days after sowing showed significant difference with various treatments. The maximum plant height (52.80 cm) was obtained in the treatment T_{14} (200 ppm GA_3 + 100 ppm NAA). It increased the plant height significantly over control and rest of the treatments. The treatment T_{14} increased the plant height by 33.67 per cent over control and it was statistically at par with the treatment T_{15} and T_{13} (Table 3). It is observed fact, that GA_3 act in cell elongation or cell enlargement resulting in increased in size and number of leaves. Similar result was also reported by Baraskar *et al.* (2018) in okra. The maximum number of leaves plant^{-1} (45.20) was obtained with the treatment T_{15} (200 ppm GA_3 + 200 ppm NAA) at the time of last harvesting (cumulative). It significantly increased the number of leaves plant^{-1} as compared to control. It is well established fact that GA_3 and NAA act by cell elongation resulting in increased number of leaves.

The similar results were also reported by Mandal *et al.* (2012) and Chowdhury *et al.* (2014), Baraskar *et al.* (2018) in okra. It is clear from the data (Table 3) that, days taken to first flowering marginally reduced with the application of GA_3 and NAA as foliar application. Among all the treatments minimum 40.50 days taken to first flowering was recorded under the treatment T_9 (50 ppm GA_3 + 200 ppm NAA) and maximum 45.48 days taken to first flowering was under control. This might be due to NAA 200 ppm which most important primary site of action as the cell division is stimulated in the shoot apex especially more in basal maristematic cells from which large files of cortex and pith cells develop. These results were in conformity with those of Patil and Patel (2010) and Singh *et al.* (2012) in okra. Application of medium dose of GA_3 (100 ppm) was found to have significant effect on chlorophyll content of leaves with highest SPAD value (53.57) in treatment T_7. The treatments T_3, T_4, T_7 and T_{12} also recorded significantly higher chlorophyll content of leaves than that of control, but these were at par with each other. Earlier results by Chatterjee and Choudhuri (2012) revealed that maximum chlorophyll content (SPAD value 52.30) of leaves was observed in the plots sprayed with GA_3 150 ppm.

The significant variation in the fruits yield parameters was noted under different treatments (Table 3). The maximum number of fruits per plant (12.60) was recorded under the treatment T_{15} (200 ppm GA_3 + 200 ppm NAA). Treatment T_{15} recorded 40.0 per cent increase in number of fruits over control. The treatments T_{14}, and T_{13} also recorded significantly higher number of fruits than that of control, but these were at par with T_{15}. There was significant variation in the number of picking due to different treatments. The maximum number of picking (12.49) was recorded in the treatments T_{15} followed by T_{14} and T_{13}, respectively. All these treatments showed higher number of pickings than the control but these treatments did not differ significantly from each other. The minimum numbers of picking (9.0) was found in control. The maximum duration of harvesting (47.0 days) was found under the treatment T_6 (NAA 200 ppm), which was found non-significantly higher than control and rest of the treatments. There was significant variation in fruit length, fresh weight of fruits, and quality score of fruits with various treatments (Table 4). The maximum fruit length (10.90 cm) was obtained with T_{15} (200 ppm GA_3 + 200 ppm NAA) that was significantly higher than all treatment including control. The increase in fruit length could be due to cell elongation. The results were supported by Ravat and Makani (2015) and Meena *et al.* (2017) in okra.

The maximum fresh weight of green fruit (10.69 g) was recorded in T_{15} (200 ppm GA_3 + 200 ppm NAA), which was closely followed (10.68 g) by the treatment T_{14} and the minimum (7.89 g) was recorded in control (T_0). The maximum quality score of fruit (8.50) was recorded with the foliar application of T_{15} (200 ppm GA_3 + 200 ppm NAA) which was found to be significantly higher over rest of the treatments including control but at par with T_{14}, T_{13}, T_{11}, T_{10} and T_8. The analysis of variance exhibited significant variation among the treatments for yield of fruits per hectare.

All the treatments showed significantly higher yield than control. Treatment T_{15} (200 ppm GA_3 + 200 ppm NAA) obtained higher yield (67.34 q ha^{-1}) that was at par with T_{14} in the descending order. Earlier results by Kokare *et al.* (2006) revealed that maximum plant height was observed in the plots sprayed with GA_3 200 ppm, while spraying the plants with NAA 200 ppm resulted in increase in number of leaves, leaf area, plant dry weight, number of fruits, fruit girth, fruit yield per plant, fruit yield (t/ha) and ascorbic acid content over the control (sprayed with distilled water). Ayyub *et al.* (2013) also reported enhanced vegetative and reproductive growth of okra in response to 100 ppm of GA_3, applied after three weeks of sowing. More or less similar effect of GA_3 and NAA has been obtained on okra crop with respect to variation in yield attributes of various cultivars at different climatic conditions by Meena *et al.* (2017).

The maximum net return (Rs. 132867.5 per hectare) was recorded under the treatment T_{15} (200 ppm GA_3 + 200 ppm NAA) with benefit cost ratio of 2.74:1 which was very close to T_{14} and T_{13} (Table 4). Similarly, from the economics point of view, NAA was found to be profitable as compared to rest of treatments reported by Patil and Patel (2010) in cv. GO-2 with variable concentration. Mandal *et al.* (2012) and Meena *et al.* (2017) earlier found that, concentrations of plant growth regulators caused an increased in net return and B:C ratio over the control, but the differences were much narrower.

Effect of GA_3 and NAA on cowpea

The application of plant hormones (GA_3 and NAA) both alone or in combination significantly improved growth and fruiting related traits. The results (Table 5) indicated that vine length at maturity was greatly increased by the application of NAA 100 ppm (68.85 cm) followed by the application of 100 ppm GA_3 + 100 ppm NAA (68.00 cm), whereas minimum vine length was found in controlled (59.83 cm). Same trends were also found in number of leaves $plant^{-1}$ as NAA 100 ppm (48.80) showed the highest followed by NAA 100 ppm + GA_3 100 ppm (47.90) and minimum leaves (41.20) with GA_3 100 ppm + NAA 100 ppm (T_{15}). Same results were observed by Shahid *et al.* (2013) and Meena *et al.* (2017) in okra. Significantly less number of days was required for days to 1^{st} flowering (42.48) with the treatment 200 ppm GA_3 + 100 ppm NAA (T_{14}) which was at par with (T_{15}) GA_3 200 ppm + NAA 200 ppm (43.88 days), T_{13} (42.68 days), T_{12} (45.28 days), T_{11} (44.78 days), T_{10} (43.48 days) and T_7 (44.91 days), as compared to control and rest of the treatments (Table 5). This might be due to the reason that GA_3 reduced the days required for flowering which ultimately led towards early flower production.

These results were supported by Singh and Kumar (2005) and Bhagure and Tambe (2013). Significantly higher chlorophyll content of leaves (61.68 SPAD value) were observed when 100 ppm GA_3 + 100 ppm NAA (T_{11}) was sprayed to plants, which was at par with T_{14}, T_{13}, T_{12}, T_{10}, T_8, T_7, T_6 and T_5. More number of pods gives an idea about yield, here the combination of GA_3 and NAA *i.e.* 200 ppm GA_3 + 50 ppm NAA (T_{13}) showed maximum number of pods per plant (37.44) followed by T_{14} (24.33), T_{12} (36.40) and T_{11} (36.30). This might be due to more number of nodes per plant in case of above said combinations. The result coincides with the findings of Patil and Patel (2010) and Mehraj *et al.* (2015). Mean data revealed that pods yield $plant^{-1}$ varied from 122.5g to 198.85 g. Maximum pods yield $plant^{-1}$ (198.85 g) was observed with the application of 100 ppm GA_3 + 100 ppm NAA (T_{11}) and it was significantly superior treatment. The minimum pods yield $plant^{-1}$ (122.50) was recorded in control. It is amply clear from the study that exogenous application of plant growth regulators stimulate the effects of enzymatic activities of natural occurring hormones that accelerated and modified the growth and development of plants and hence increase pods yield $plant^{-1}$. The results are in line with the findings of Satodiya *et al.* (2011) in cluster bean, Patel *et al.* (2011) and Golakiya *et al.* (2017) in cowpea.

The highest pod length (31.41 cm) was observed with 100 ppm GA_3 + 200 ppm NAA (T_{12}), which was significantly higher as compared to control (25.18 cm). Treatments T_4 (27.20 cm), T_5 (27.80 cm) and T_6 (27.60 cm) and rest of the treatments were at par with T_{12} treatment. The increase in fruit length could be due to cell elongation. The results were supported by Kokare *et al.* (2006) and Ravat and Makani (2015) in okra. The highest fresh weight of pod (5.54g) recorded with 100 ppm GA_3 + 50 ppm NAA (T_{10})

followed by T_{11} (5.49g), T_{12} (5.29g) and T_8 (5.25g) was significantly superior over control (4.31g) and rest of the treatments. This might be due to the growth by cell division, cell enlargement and cell expansion which ultimately improved the fruit weight. These results were supported by Singh and Kumar (2005) and Katung *et al.* (2007). The quality score of fruit was recorded highest (8.12) under 100 ppm GA_3 + 100 ppm NAA (T_{11}) followed by 100 ppm GA_3 + 50 ppm NAA (T_{10}) which was non-significant with control. Foliar application of gibberellic acid and NAA had been reported to affect number of pods plant^{-1}, pod yield plant^{-1} as well as fresh weight of pod. Therefore, impact of PGRs was also assessed on pod yield and quality. Fresh pod yield ha^{-1} was found maximum (99.64 q ha^{-1}) from plants sprayed with solution containing 100 ppm GA_3 + 100 ppm NAA (T_{11}) followed by T_{10} treatment (97.28 q ha^{-1}) and statistically it surpassed all other treatments and control (Table 6). While minimum pod yield (61.42 q ha^{-1}) was noted in control (T_0). It is clear from the results that treatments comprising of both GA_3 and NAA at medium concentration improved pod yield significantly as compared to their application alone or in combination at low (50 ppm) as well as higher concentrations (200 ppm). The data presented in Table 6 revealed that among the different combination of treatments T_{11} (GA_3 100 ppm + NAA 100 ppm) registered the highest net return Rs. 133394.0 ha^{-1} with maximum B: C ratio value of 3.81: 1 as compared to rest of the treatment combinations. Moreover, the next best treatment was T_{10} (GA_3 100 ppm + NAA 50 ppm) which registered the net return of Rs. 129380.1 ha^{-1} with B: C ratio of 3.70: 1. Whereas, treatment T_0 (control) recorded the lowest net return of Rs. 70409.7 ha^{-1} with lowest B: C ratio of 2.01: 1.

From the above results it may be concluded that plant growth regulators *i.e.* gibberellic acid and napthalene-acetic-acid have significant effect in increasing growth, development and yield of cluster bean, okra and cowpea with different concentration of both. However, GA_3 is found to be a superior growth regulator as compared to respective doses of NAA. Growth regulators were less effective when applied individually as compared to their combined use, however performance of plants treated with individual growth regulator was better than the untreated plants. The improvement in growth as a result of GA_3 and NAA might be attributed to their function in stimulation of metabolic activities and hormonal regulation. GA_3 and NAA stimulate the growth of plant tissues there by enhancement in cell multiplication and cell elongation resulting increased growth of plant. It could be concluded that among the different combination of treatments in cluster bean GA_3 100 ppm + NAA 200 ppm, in okra GA_3 200 ppm + NAA 200 ppm and in cowpea 100 ppm GA_3 + 100 ppm NAA were found the most suitable treatments for maximum production, highest net return with maximum B: C ratio as compared to rest of the treatments.

Table 1. Effect of NAA and GA_3 on different growth and yield attributes of cluster bean

Treatments	Plant height at maturity (cm)	No. of leaves plant^{-1}	No. of days taken to first flowering	Chl. content (SPAD Value)	No. of cluster plant^{-1}	No. of pods cluster^{-1}	Number of pods plant^{-1}
T_0	96.23	87	44.67	49.67	16.48	14.68	242.01
T_1	96.72	90	42.96	51	17.68	15.78	279.08
T_2	97.3	94	41.25	51.01	18.48	15.88	293.56
T_3	96.87	88	40.87	53.11	19.08	16.18	308.81
T_4	97.08	94	40.63	54	17.1	14.11	241.65
T_5	97.93	99	42.33	54.3	16.5	15.1	249.53
T_6	98.38	97	42.94	55.5	17.47	15.8	276.35
T_7	96.9	92	37.9	56.6	19.02	15.76	299.74
T_8	97.77	94	39.3	57.3	19.82	16.48	326.62
T_9	98.72	99	39.7	57.7	19.42	16.08	312.26
T_{10}	96.44	95	36.12	58.1	19.55	16.51	322.83
T_{11}	96.92	96	37.43	59.9	19.95	16.91	337.41
T_{12}	97.29	96	37.93	60	20.25	17.02	344.71
T_{13}	96.85	92	35.4	61.2	18.91	15.91	300.86
T_{14}	97.64	91	36.6	61.7	18.51	15.81	292.65
T_{15}	97.95	88	35.2	62.3	18.41	15.51	285.54
SEm	0.774	2.059	1.24		0.7		1.641
CD 5%	2.322	6.179	3.74	NS	2.101	NS	4.925

Table 2. Effect of NAA and GA_3 on yield attributes and economics of cluster bean

Treatments	Pod length (cm)	Fresh weight of pod (g)	Quality score of fruit (10)	Yield (q ha^{-1})	Net Return (Rs.)	B: C ratio
T_0	6.29	0.69	7.02	83.48	168434.1	2.05
T_1	5.86	0.7	7.55	98.13	211885	2.58
T_2	5.83	0.69	7.83	100.77	219817.1	2.68
T_3	6.23	0.69	7.82	106.52	237073.8	2.89
T_4	5.68	0.63	7.34	76.86	148078.4	1.81
T_5	5.96	0.64	7.52	80.6	159297.4	1.94
T_6	5.08	0.65	7.75	90.61	189329.3	2.31
T_7	6.14	0.68	8.01	101.9	222694.4	2.72
T_8	5.78	0.63	8.25	102.87	225613.5	2.75
T_9	5.56	0.62	8.15	96.79	207359.3	2.53
T_{10}	5.08	0.65	8.32	105.47	233417.4	2.85
T_{11}	5.86	0.66	8.02	111.92	252771.7	3.08
T_{12}	6.06	0.67	8.44	116.07	265207.5	3.23
T_{13}	5.98	0.74	7.55	111.33	250993.6	3.06
T_{14}	6.58	0.73	7.8	106.83	237485.1	2.9
T_{15}	5.4	0.71	8	101.38	221139.8	2.7
S. Em ±	-	-	0.85	1.641	-	-
CD 5%	NS	NS	0.253	4.925	-	-

Table 3. Effect of NAA and GA_3 on different growth and yield attributes of okra

Treatments	Plant height at maturity (cm)	No. of leaves $plant^{-1}$	No. of days taken to first flowering	No. of fruits $plant^{-1}$	No. of picking	Chl. Content (SPAD Value)	Duration of picking (days)
T_0	39.5	33.5	45.48	9	8.99	46.07	38.5
T_1	42.3	35.4	42.08	10.3	9.99	49.57	39.1
T_2	43.5	36	42.48	10.6	10.99	53.57	40
T_3	42.1	33.5	42.98	10.7	10.49	52.07	42.5
T_4	47.9	30.7	44.5	10	10	51.23	42.5
T_5	46.9	36.7	44.5	10.3	10.5	49.23	46.7
T_6	45.3	32.5	42.5	10.7	11	47.53	47
T_7	49.5	38.5	41.3	11.5	11	51.6	43.5
T_8	46.3	39	42.7	11.8	11.5	49.8	44
T_9	46.7	40.5	40.5	12	11	48.5	45
T_{10}	49.49	39.59	41.19	11.9	11.5	46.97	45.5
T_{11}	49.49	41.49	42.69	12	11.5	49.07	46
T_{12}	47.49	42.09	42.89	12.09	10.99	51.67	44.5
T_{13}	49.7	43.8	41.3	12.5	11.99	48.67	45.7
T_{14}	52.8	44.5	42.2	12.5	12.45	46.27	45.5
T_{15}	50.7	45.2	42.3	12.6	12.49	44.37	45
S Em ±	0.552	0.551	0.66	0.148	0.103	1.413	-
CD 5%	1.597	1.592	1.908	0.429	0.298	4.082	NS

Table 4. Effect of NAA and GA_3 on yield attributes and economics of okra

Treatments	Fruit length (cm)	Fresh weight of fruit (g)	Quality score of fruit (10)	Yield ($q.ha^{-1}$)	Net Return (Rs.)	B: C ratio
T_0	8.5	7.89	7.3	35.52	56300	1.16
T_1	8.69	7.99	7.49	41.17	68414.2	1.41
T_2	8.7	8.19	7.7	43.42	74061.7	1.53
T_3	8.91	8.49	7.75	45.44	79098.3	1.63
T_4	9.5	8.4	7.3	42	70500	1.45
T_5	9.71	8.7	7.5	44.81	77512.5	1.6
T_6	9.8	8.8	7.75	47.08	83200	1.72
T_7	8.85	9.2	8	52.94	96836.3	2
T_8	8.9	9.6	8.25	56.68	106189.2	2.19
T_9	9.3	10	8.1	60.04	114591.7	2.36
T_{10}	9.4	10.2	8.3	60.73	116317.1	2.4
T_{11}	9.6	9.8	8.4	58.84	111590.8	2.3
T_{12}	9.49	10.29	8.05	62.19	120007.6	2.47
T_{13}	9.95	10.49	8.25	65.55	128406.3	2.65
T_{14}	10.5	10.68	8.39	66.8	131531.3	2.71
T_{15}	10.9	10.69	8.5	67.34	132867.5	2.74
S Em $\pm$	0.099	0.901	0.103	0.276	-	-
CD 5%	0.298	0.29	0.297	0.799	-	-

Table 5. Effect of NAA and GA_3 on different growth and yield attributes of cowpea

Treatments	Vine length at maturity (cm)	No. of leaves $plant^{-1}$	No. of days taken to first flowering	Chl. content (SPAD value)	Number of pods $plant^{-1}$	Pod yield $plant^{-1}$ (g)
T_0	59.83	42.33	51.88	49.67	28.5	122.5
T_1	65.53	43.13	50.18	50.67	29	131.04
T_2	67.03	44.03	48.48	52.87	30.1	138.13
T_3	65.73	44.93	48.08	55.07	27.51	124.84
T_4	67.8	46.9	48.58	56.57	30.26	136.54
T_5	68.85	48.8	50.28	57.67	30.81	139.94
T_6	66.05	46.7	50.88	60.87	32.45	141.85
T_7	66.28	44.53	44.91	61	34.53	172.48
T_8	67.73	45.73	46.31	58.2	33.67	176.6
T_9	66.38	45.13	46.71	56.71	33.57	172.71
T_{10}	67.05	45.1	43.48	61.28	35.12	194.13
T_{11}	68	47.9	44.78	61.68	36.3	198.85
T_{12}	66.17	45.8	45.28	57.98	36.4	192.12
T_{13}	65.37	42.1	42.68	60.27	37.44	192.48
T_{14}	64.7	41.5	42.48	61.37	36.54	184.19
T_{15}	63.1	41.2	43.88	55.27	34.81	170.24
S. Em $\pm$	1.451	1.264	1.175	1.483	1.175	1.42
CD 5%	4.354	3.792	3.527	4.284	3.527	4.102

Table 6. Effect of NAA and GA3 on yield attributes and economics of cowpeap

Treatments	Pod length (cm)	Fresh weight of pod (g)	Quality score of fruit (10)	Production ($q.ha^{-1}$)	Net Return (Rs.)	B: C ratio
T_0	25.18	4.31	6.69	61.42	70409.7	2.01
T_1	28	4.53	7.22	65.69	76164.5	2.18
T_2	28.5	4.6	7.5	69.23	82191	2.35
T_3	28.2	4.55	7.49	62.59	70894.9	2.03
T_4	27.2	4.5	7.71	68.09	80244.5	2.29
T_5	27.8	4.53	7.89	69.78	83133.9	2.38
T_6	27.6	4.36	7.59	70.74	84759.7	2.42
T_7	29.53	5	7.71	86.39	110864.5	3.17
T_8	30.13	5.25	7.95	88.45	114362.7	3.27
T_9	29.73	5.15	7.85	86.51	111062.4	3.17
T_{10}	31.6	5.54	8.01	97.28	129380.1	3.7
T_{11}	31	5.49	7.89	99.64	133394	3.81
T_{12}	31.41	5.29	8.12	96.28	127672.6	3.65
T_{13}	30.75	5.15	7.22	96.41	127893.6	3.65
T_{14}	30.1	5.05	7.47	92.26	120848	3.45
T_{15}	29.51	4.9	7.67	85.28	108983.7	3.11
S. Em $\pm$	1.141	0.095	-	1.024	-	-
CD 5%	3.297	0.287	NS	3.072	-	-

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