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Effect of BP-100 and growth regulators on growth and yield of Okra (*Abelmoschus esculentus* L. Moench)

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ABSTRACT

The field experiment was carried out during *kharif* season of 2022 to study the effect of growth regulators on growth and yield of okra. The experiment was planned using randomized block design with nine treatments and three replications comprising three levels of biopolymer BP - 100 (2.5,5,10kg/acre) and two levels of growth regulators viz., GA3 (50,100 ppm) and NAA (50, 100 ppm) and one combination GA3 and NAA (50 ppm + 50 ppm) and Control. Results revealed that that the application of BP-100 (5 kg/acre) significantly enhanced morpho-physiological traits *viz.*, plant height (103.90 cm), number of branches plant^{-1} (3.87), number of nodes plant^{-1} (21.94), number of leaves plant^{-1} (23.34), internodal length (7.27cm), days to first flowering (39.5), days to 50% flowering (44.93) and yield parameters *viz.*, number of fruit plant^{-1} (9.72), fruit length (13.96 cm), fruit girth (1.67 cm), fresh fruit weight (14.03g), yield (41.55q/acre) are found to be effective compared to control and rest of the treatments.

Key words: *GA3, NAA, Growth regulators, BP-100, Yield, Okra*

Introduction

Okra (*Abelmoschus esculentus* L. Moench) is a widely recognized vegetable grown in tropical and subtropical regions (Marin *et al.*, 2017). It belongs to the Malvaceae family and thrives in warm climatic conditions. Its resilience to heat makes it suitable for cultivation without the need for advanced technology (Oliveira *et al.*, 2003). However, it is sensitive to frost, low temperatures, waterlogging, and drought. For optimal seed germination, a temperature of around 29°C is required. Okra prefers well-drained sandy loam soil with a pH range of 6-6.8 and exhibits moderate salt tolerance. While primarily consumed for its green tender fruits, okra's economic importance is growing due to increasing local and global demand. It is also utilized for oil production, biofuel, and medicinal purposes. Various factors influence the growth and production of okra, including nutrition, seed quality, cultural practices and weather conditions. Plant growth regulators, such as hormones, can affect plant growth and development by modulating natural growth regulatory mechanisms. They play vital roles in controlling physiological processes such as cell division, elongation, differentiation, flowering, fruiting, and senescence. Additionally, plant growth regulators can interact with environmental factors like light, temperature, humidity, and nutrient availability, thereby impacting plant responses and adaptability. These regulators can enhance plant physiological efficiency, including photosynthetic capacity and assimilate partitioning efficiency, thus promoting field crop production.

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Poly-gamma-glutamic acid (γPGA) is a biodegradable, non-toxic, environmentally friendly, and non-immunogenic biopolymer. It is primarily produced by gram-positive bacteria of the Bacillus genus, such as *B. subtilis*, *B. licheniformis* and *B. subtilis* subsp. natto, and is released into the extracellular environment as an energy source for microorganisms (Hsueh *et al.*, 2017). γPGA acts as a natural biostimulant, stimulating plant growth and development. It enhances nutrient uptake, promotes root growth, improves photosynthesis efficiency, and enhances stress tolerance in plants. Furthermore, its water retention properties contribute to soil moisture management and help alleviate water stress in plants

Materials and Methods

The experiment was conducted at the Agriculture Research Farm, School of Agriculture, Lovely Professional University, Phagwara (Punjab) during *kharif* season, 2022. The field experiment was laid out in Randomized Block Design with three replications and nine treatments. The treatment comprised of three levels of biopolymer BP -100 [T2 (2.5kg/acre), T3 (5kg/acre) and T4 (10 kg/ acre) and two levels of growth regulators viz., GA3 [T5 (50ppm) and T6 (100 ppm)] and NAA [T7 (50ppm) and T8 (100 ppm)] and one combination GA3 and NAA [T9 (50ppm + 50ppm) and one untreated [T1] as Control. BP-100 (A super-natural bio Polymer- Poly Gamma Glutamic Acid) is a soil vitalizer- super natural biopolymer containing humic acid and seaweed extract. BP-100 is a newly introduced product from Plantbiotix Bio Agri Division of Zytex Biotech Pvt. Ltd. Okra variety Punjab Suhawani was taken as test crop. The seeds were dibbled at the spacing of 45 x 15 cm. The recommended dose of phosphorus (P_2O_5), potassium (K_2O), and one-third of nitrogen (N) was applied during the field preparation stage. The remaining nitrogen was divided into two split doses and applied at 30 and 60 days after sowing (DAS). Additionally, all cultural and management practices were uniformly followed for all the treatments. BP-100 was applied at the time of seedling growth and pod formation stage through drenching. GA3 and NAA was applied at 30 and 60 DAS by foliar spray. Observations were recorded on five randomly selected plants for each treatment. The statistical analysis of data was performed using OPSTAT software.

Results and Discussion

Growth parameters

Plant Height (cm)

The result on the plant height indicated that application of BP-100, GA3, NAA, on okra has increased plant height as compare to control. The maximum plant height (103.90) was recorded in the treatment (T3) BP-100 (5kg/acre) followed by the treatment (T6) GA3 100ppm (100.02) and the minimum plant height (79.02) was observed in the treatment (T1) Control. The observed increase in plant height in treatment T3 may be attributed to the application of humic acid. (as shown in Table 1) Humic acid has been found to enhance the uptake of calcium, which plays a significant role in the mitotic cell division of apical meristems, thereby influencing plant height. This finding is consistent with the observations made by Haider *et al.* (2017) in their study on okra. Kirn *et al.*, 2010 and Gad *et al.*, 2015 found similar results when they revealed a substantial influence of humic acid on plant height of okra plants. Zodape *et al.* (2011) also showed that using seaweed extract (5.0%) as a foliar spray resulted in increased plant height.

Number of branches plant^{-1}

The results indicated that the maximum number of branches (3.87) was recorded under the treatment (T3) BP-100 (5kg/acre) followed by the treatment (T6) GA3 100ppm (3.40) and the lowest number of branches per plant (2.21) were recorded in the treatment (T1) Control. The highest number of branches was observed in the treatment (T3), which might be attributed to the application of humic acid, which would have boosted soil fertility by increasing nutrient availability (as shown in Table 1). Pizzeghello *et al.* (2001) investigated the hormone activity of humic substances, which had similar effects to auxin and may have contributed to the rise in the number of branches.

Number of nodes plant^{-1}

The data analysis revealed that the mean number of nodes per plant was significantly affected by the various treatments applied. The maximum number of nodes (21.94) was recorded under the treatment (T3) BP-100 (5kg/acre) followed by the treatment (T6) GA3 100 ppm (20.82) and the lowest number of nodes per plant (15.18) were recorded in the treatment (T1) Control. Maximum number of nodes per plant reported in treatment (T3) may be related to increased protoplasm assimilation, which may result in more cell division, creation of more tissues, and plant vigour. Zubaid (2018) reported similar findings (as shown in Table 1).

Internodal length (cm)

The results indicated that internodal length was increased (7.27) under the treatment (T3) BP-100 (5kg/acre) followed by the treatment (T6) GA3 100ppm (6.34) whereas minimum internodal length (4.31) was found under the treatment (T1) Control. The maximum internodal length observed in treatment T3 can be attributed to the higher absorption of nutrients, particularly nitrogen. This increased nutrient uptake is believed to have stimulated cell division and elongation, leading to enhanced metabolic activity in the meristematic tissues. These factors collectively contributed to the increase in internodal length. This observation is in line with the findings of Pandey *et al.* (1994).

Number of leaves plant^{-1}

The data in respect of mean number of leaves per plant was significantly influenced by different treatments (as shown in Table 1). The maximum number of leaves (23.34) was recorded under the treatment (T3) BP-100 (5kg/acre) and it was statistically at par with treatment (T6) GA3 100 ppm (22.37) and the lowest number of leaves per plant (17.00) were recorded in the treatment (T1) Control. The increase in the number of leaves per plant in the treatment (T3) might be attributed to enhanced nutrient availability and absorption, which promoted plant development and increased plant height, both of which are important factors in the number of leaves (Haider *et al.,* 2017) in okra. The positive effects of humic acid soil drench on plant development parameters can be attributed to the improvement of soil physical and chemical properties. The application of humic acid may lead to increased cell membrane permeability, enhanced oxygen absorption, improved respiration and photosynthesis rates, increased phosphate uptake, enhanced root and cell elongation, and improved ion transport. These findings align with the research conducted by Shafeek *et al.* (2016). Additionally, Yildirim *et al.* (2007) observed similar results and reported that the addition of humic acid increased the number of leaves in various plant species.

Days to first flowering

The significantly minimum days taken for initiation of first flower (39.5) under the treatment (T3) BP-100 (5kg/acre) and the maximum days taken for initiation of first flower (46.0) was observed under the treatment (T1) Control (as shown in Table 1). Humic acid increased the chlorophyll content in leaves and increased nitrogen intake from the soil, which aided in early blooming (Haider *et al.,* 2017). Similar finding was reported by Javanmardim and Hasanshaian (2014).

Days to 50% flowering

The data recorded on number of days required for 50 percent flowering were reduced (44.93) in treatment (T3) BP-100 (5kg/acre) followed by the treatment (T6) GA3 100 ppm (45.88) were resulted in earlier production of 50 percent flowering significantly

Table 1. Effect of BP-100 & growth regulators on growth parameters of okra

Treatment details	Plant height (at harvest) (cm)	Number of branches plant^{-1}	Number of nodes plant^{-1}	Internodal length (cm)	Number of leaves plant^{-1}	Days to first flowering
T1{Control (RDF)}	79.02	2.21	15.18	4.31	17.00	46.0
T2 {BP-100(2.5kg/acre)}	91.94	2.92	17.99	5.58	20.51	42.9
T3 {BP-100 (5kg/acre) }	103.90	3.87	21.94	7.27	23.34	39.5
T4 {BP-100(10kg/acre)}	95.86	3.10	18.09	6.09	20.61	41.8
T5 {GA3 (50ppm) }	93.14	2.78	18.33	5.71	19.82	42.6
T6{GA3 (100ppm) }	100.02	3.40	20.82	6.34	22.37	40.7
T7 {NAA (50ppm) }	96.53	2.85	18.77	5.75	19.89	42.0
T8 {NAA (100ppm) }	98.87	3.29	20.22	6.19	21.87	41.5
T9 {GA3 + NAA(50ppm+ 50ppm)}	97.05	2.96	18.33	6.00	20.95	41.4
SE(±m)	1.74	0.20	0.51	0.42	0.49	0.54
CD (P=0.005)	3.69	0.44	1.09	0.91	1.10	1.1

at earlier DAS as compared to treatment (T1) control (53.17). The observed early flowering in treatment T3 can be attributed to the increased nutrient uptake facilitated by the application of humic acid. Humic acid acts as a hormone within the plant, stimulating cell elongation and enhancing fungal and microbial activity in the soil, which in turn promotes plant growth and development. This finding is consistent with the research conducted by Haider *et al.* (2017; Rana *et al.*, 2021). Additionally, Kumar *et al.* (2015) reported similar results, demonstrating early flowering in okra with the application of humic acid (as shown in Table 2).

Yield parameters Number of fruit plant^{-1}

Results revealed that the maximum number of fruits per plant (9.72) were observed in (T3) BP- 100 (5 kg/acre) followed by (T6) GA3 100ppm (8.54) and the minimum number of fruits per plant in observed in (T1) Control (5.69). Zodape *et al.* (2008) were also reported plant sprayed with liquid seaweed fertilizer increase in fruit yield (20.47%) and number of fruits (37.47%) per plot than other treatments (Table 2).

Fruit length (cm)

The results indicated that the maximum fruit length (13.96) was recorded in (T3) BP-100 (5kg/acre) followed by (T6) GA3 100 ppm (13.36) and minimum fruit length (11.57) was recorded in (T1) Control (Table 2). The increase in fruit length the treatment (T3) might me due to humic acid is used because it functions as a hormone, causing cell elongation, cell division, and nutrient absorption, which may result in increased fruit length. Foliar application of humic acid resulted in significant increase in pod length of cowpea (Azarpour *et al.*, 2011). Similar findings were also reported by Zaky *et al.* (2006) in beans.

Fruit girth (cm)

The data regarding fruit girth was significantly influenced by different treatments (Table 2). The highest fruit girth (1.67) was recorded in the (T3) BP-100 (5kg/acre) which was significantly superior over (T1) control (1.35). Humic acid stimulates the chlorophyll concentration of the leaf, resulting in high photosynthetic activity and maximal photosynthate absorption. This transfer of food material to the fruit increases fruit diameter (Haider *et al.*, 2017). Yildirim (2007) has reported a significant enhancement in fruit diameter as a result of exogenous humic acid application in tomato.

Fresh Fruit weight (gm)

Result revelead that the data of fresh fruit weight was significantly influenced by different treatments. The fresh fruit weight (14.03) observed with (T3) BP-100 (5kg/acre) were at par with (T6) GA3 100 ppm (13.57) was significantly higher as compared to (T1) control (11.66) and rest of the treatments. (as shown in Table 2). The maximum fresh weight of fruit was recorded in T3 treatment and it was due to vegetative growth that led to increased photosynthesis accumulation of more carbohydrates, consequently maximum fresh weight of fruit. Similar results were reported by Bharati *et al.* (2018) and Somendrameena *et al.* (2017).

Yield (q/acre)

The result on the yield indicated that application of BP-100, GA3, NAA, on okra had higher production

Table 2. Effect of BP-100 & growth regulators on yield parameters of okra

Treatment details	Days to 50% flowering	Number of fruit plant^{-1}	Fruit length (cm)	Fruit girth (cm)	Fresh Fruit weight (g)	Yield (q/acre)
T1{Control (RDF)}	53.17	5.69	11.57	1.35	11.66	24.97
T2 {BP-100(2.5kg/acre)}	47.07	7.82	12.99	1.43	12.98	34.43
T3 {BP-100 (5kg/acre) }	44.93	9.72	13.96	1.67	14.03	41.55
T4 {BP-100(10kg/acre)}	46.83	8.20	13.16	1.52	13.02	37.71
T5 {GA3 (50ppm) }	46.44	7.58	13.11	1.48	12.83	35.96
T6{GA3 (100ppm) }	45.88	8.54	13.36	1.57	13.57	39.07
T7 {NAA (50ppm) }	46.31	7.61	12.85	1.44	12.87	36.48
T8 {NAA (100ppm) }	46.18	8.48	13.27	1.55	13.17	38.91
T9 {GA3 + NAA(50ppm+ 50ppm)}	46.34	8.08	13.14	1.48	13.19	38.56
SE(±m)	0.41	0.41	0.26	0.04	0.30	1.09
CD (P=0.005)	0.87	0.88	0.56	0.09	0.64	2.32

as compared to control. The maximum yield (41.55) was recorded in the treatment (T3) BP-100 (5kg/ acre) followed by the treatment (T6) GA3 100 ppm (39.07) and the minimum yield (24.97) was observed in the treatment (T1) Control. Humic acid application helps to increase yield attributing characters by activating hormones such as auxin and cytokinin and increasing cell division and enlargement, as well as maintaining higher soil water potential and increasing nutrient holding capacity of soil, resulting in higher plant growth in terms of height, number of leaves, number of nodes, and number of branches per plant, which ultimately increases yield. Similar results were reported by Haider *et al.* (2017); Kumar *et al.* (2015); Rana *et al.*, 2023 and Zodape *et al.*, (2008). (as shown in Table 2).

Conclusion

The application of BP-100, GA3, and NAA had significant effects on all growth parameters and yield parameters of okra. Based on the results obtained, it can be concluded that the application of BP-100 at a rate of 5 kg per acre was found to be the most effective treatment across all parameters. Following BP-100, the application of GA3 at a concentration of 100 ppm also showed notable effectiveness.

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