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Influence of Different Plant Growth Regulators and Boron on Growth, Yield and Sex Expression of Bottle Gourd (*Lagenaria siceraria* Mol.) under Garhwal Valley

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out at Horticultural Research Centre, Department of Horticulture, H. N. B. Garhwal University, Uttarakhand, India during summer season, 2018-19. The existing experiment was laid out in randomized block design following 13 treatments replicated thrice. The various growth parameters as well as yield attributes and yield were recorded during the experimentation. The result of the present investigation showed that GA_3 @ 50 mg/kg was registered as the best treatment in terms of vine length (376.13 cm), fruits per vine (6.60), sex ratio (F:M) 1:11.07 and yield per vine (1357.33 g) and NAA @ 200 mg/kg+ Boron @ 0.1% with relation

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to the number of main branches per vine (10.87), length of fruit (24.57 cm), diameter of fruit (90.10 mm), yield per plot (10.29 kg/plot) and yield per hectare (457.33 q) in bottle gourd. However, GA_3 @ 50 mg/kg+ Boron @ 0.1% number of node per vine (24.27), number of node bearing first flower GA_3 50 @ mg/kg(4.20) and NAA @ 150 mg/kg(4.20), weight of fruit NAA @ 100 mg/kg+ Boron @ 0.1% (838.0 g) , total soluble solid GA_3 @ 30 mg/kg(5.04 ºBrix) and NAA @ 200 mg/kg ascorbic acid (12.90 mg/100g). The cultivar (Pusa Naveen) gives better response with the application of GA_3 @ 50 mg/kg for sex expression and NAA @ 200 mg/kg+ Boron @ 0.1% for various growth and yield parameters. It can be recommended to enhance the production of bottle gourd under Garhwal valley of Uttarakhand.

Keywords: Bottle gourd; boron; PGR; sex expression; vine length and Yield.

1. INTRODUCTION

The present investigation was conducted to study the aims to explore how various factors, such as plant growth regulators and Boron, can impact the growth, yield, and sex expression of Bottle Gourd in the Garhwal Valley. Essentially, it delves into understanding the influence of specific elements on the overall development and reproductive aspects of the plant in a particular geographical region. Throughout history, the edible components of herbaceous plants have been commonly referred to as vegetables, constituting a crucial element in maintaining a nutritious diet [1]. Cucurbits, encompassing a diverse array of vegetable species, stand out as a botanical family offering a spectrum of crops endowed with both gastronomic attributes and valuable fibers. Among these, the bottle gourd, a notable member of the cucurbit family, holds significance as a seasonal vegetable. Termed as lauki, ghia, kaddu, doodhi, ghai kaddu, and more, it is extensively cultivated nationwide. The tender green fruits are utilized not only as vegetables but also in the preparation of pickles, raita, and confections. Rich in vitamins B and C, along with substantial quantities of calcium, iron, and phosphorus, the consumption of bottle gourd aids in preventing constipation and imparts a cooling effect.

Various determinants, encompassing environmental conditions, nutritional factors, cultural practices, the application of plant growth regulators (PGR), varietal characteristics, and the availability of staking, exert an influence on the economic viability of bottle gourd cultivation. The economic potential for plant growth regulators is chiefly constrained by the specific plant species and cultural conditions. Employing plant growth regulators in vegetable cultivation serves to enhance germination, ensure crop uniformity, facilitate ease of harvesting, and optimize storage conditions. Micronutrient boron (B) emerges as a pivotal factor affecting bottle gourd development and growth. Several PGRs exhibit efficacy in influencing the sex expression of bottle gourd and other cucurbits [2]. The judicious application of plant growth regulators assumes a critical role in shaping sex expression and sex ratio, with modulation influenced by environmental factors, soil fertility, elevated temperatures, and extended light exposure inducing maleness. In such scenarios, PGRs such as NAA, GA3, MH, and micronutrient (B) prove effective. GA3, for instance, promotes increased cell division, elongation of cell walls, enhanced cell wall plasticity, and permeability of cell membranes, inducing parthenocarpy and modifying yield-contributing characteristics of the plant [3]. In consideration of these factors, this experiment was designed to scrutinize the impact of boron and PGR on sex modification, growth, and yield of bottle gourd.

2. MATERIALS AND METHODS

During the summer season of 2018-19, the current field experiment was carried out at the Horticultural Research Centre, Chauras Campus, Department of Horticulture, H. N. B. Garhwal University, Srinagar (Garhwal), Uttarakhand (India). The Horticulture Research Centre, Srinagar, Garhwal is located on the northern side of the Alaknanda valley, between 78º 47' 30" E longitude, 30º 13' 0" N latitude, and 563 m msl, in the lower Himalayan region. The experiment includes 13 various treatments consisting of different plant growth regulators, boron and their combinations *viz.,* NAA, GA_3, MH, Boron and their combinations It was set up in a randomised block design with three replications using cv. Pusa Naveen obtained from IARI, New Delhi.

The use of various plant growth regulators, boron and their combinations were used at 2-true leaf stage. The whole plants were fully moistened with the solution. During the observation 5 erratically selected plants were taken from each treatment per replications. The annotations were documented on the various parameters of growth, yield and quality. The quality parameters analysis was done according to the protocol provided by Rangnna [4].

The observation was obtained from the vegetative, yield and quality parameters. For recording the vegetative parameters vine length (cm), prime branches/ vine, nodes/ vine and nodes bearing flower early were recorded. Sex ratio (F:M), fruit/ vine, fruit weight (g), fruit length (cm), fruit diameter (mm), vine yield (g), yield/plot (kg) and yield per hectare (q) were measured for the yield parameters. While, for quality parameters total soluble solid (°Brix) and ascorbic acid (mg/100g) were taken for the study.

The statistical analysis designed for each and characters analyzed was conducted using the method proposed by Panse and Sukhatme (1961) for randomized block design and statistical analysis of data. The CD (Critical Difference) at 5% level of significance for each and every parameter was done.

3. RESULT AND DISCUSSION

The exogenous uses of different crop growth regulators at 2 leaf stages significantly affected the vegetative characters of bottle gourd as shown in Fig. 1.

The highest vine length was registered with the use of GA_3 @ 50 ppm, which was found significantly superior over the rest of the treatments, whereas the minimum was obtained in MH @ 150 ppm. The increment in vine length may be due to the increase in the plasticity of the cell wall, to the hydrolysis of starch to sugars, with consequent entry of water into the cell, which causes elongation and rapid cell division, in which auxin production, protein synthesis, cellular elongation and expansion of bottle gourd vine.

Asrey et al. [5] discovered a similar result in muskmelon, and Mia et al. [6] discovered a similar result in bitter gourd. The largest number of primary branches per vine was observed when NAA at 200 mg/kg was coupled with Boron at 0.1%. The minimum, on the other hand, was measured in MH @ 150 ppm. The combined action of NAA and boron increased the number of primary branches per vine, which might be attributed to increased cell division in the cambium, higher photosynthetic activity, and quicker horizontal growth, resulting in the greatest number of lateral shoots. These findings corroborate those published by Das and Das [7] for pumpkin, Kiranmayi [8] for chilli, and Ansari and Choudhary [2] for bottle gourd. The combined usage of GA3 at 50 mg/kg+ Boron @ 0.1% resulted in the most nodes per vine, while NAA @ 200 mg/kg and control resulted in the fewest. GA3 increases the number of nodes, which may be attributed to its activity in protein synthesis, shoot apex, auxin production, cell division, bottle gourd vine expansion and lengthening. Ansari and Chowdhary [2] obtained a similar result with bottle gourd. GA3 at 50 mg/kg and NAA at 150 mg/kg had the lowest

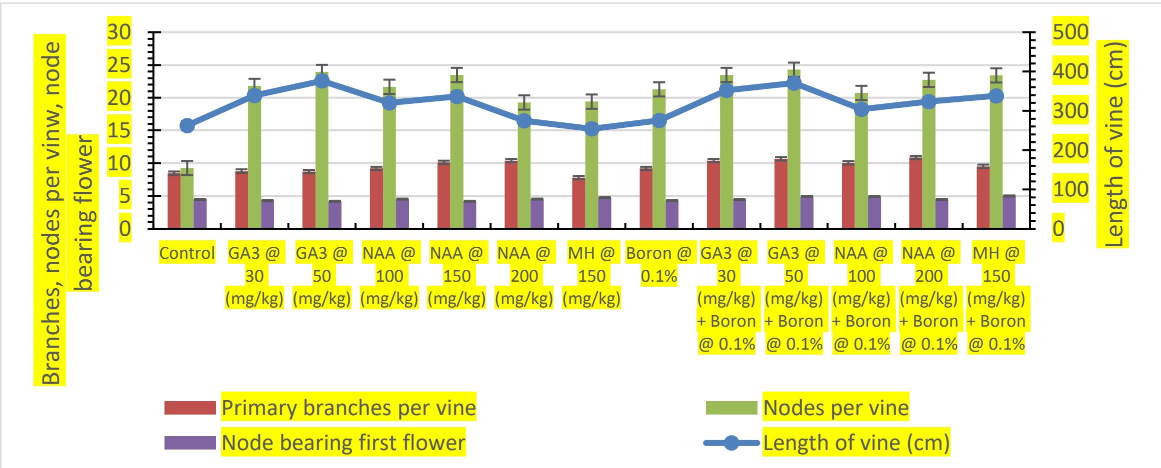

Fig. 1. Mean performances of bottle gourd *Cv*. Pusa Naveen with the impact of PGRs, boron and their combinations in case of length of vine (cm), primary branches per vine, nodes per vine and node bearing first flower

Table 1.Mean performances of bottle gourd *Cv*. Pusa Naveen with the impact of PGRs, boron and their combinations for sex ratio (F:M), fruits per vine, weight of fruit (g) and length of fruit (cm)

Treatments	Sex ratio (F:M)	Fruits per vine	Weight of fruit (g)	Length of fruit (cm)	Diameter of fruit (mm)	Yield per hectare (q)
Control	1:15.59	5.67	648.67	23.10	56.40	270.66
GA3 @ 30 (mg/kg)	1:11.69	6.53	584.0	22.97	56.80	366.66
GA3 @ 50 (mg/kg)	1:11.07	6.60	810.67	23.48	62.30	425.33
NAA @ 100 (mg/kg)	1:14.86	6.37	674.67	24.36	61.10	302.66
NAA @ 150 (mg/kg)	1:13.38	6.43	792.0	23.13	65.2	424.44
NAA @ 200 (mg/kg)	1:13.49	6.53	787.33	22.53	68.90	399.55
MH @ 150 (mg/kg)	1:12.46	6.23	730.0	22.01	67.10	438.66
Boron @ 0.1%	1:13.14	6.47	586.0	22.96	84.10	345.33
GA_3 @ 30 (mg/kg) + Boron @ 0.1%	1:12.09	6.07	676.66	22.59	70.0	346.22
GA_3 @ 50 (mg/kg) + Boron @ 0.1%	1:13.78	6.20	678.66	23.15	78.50	351.11
NAA @ 100 (mg/kg) + Boron @ 0.1%	1:12.14	6.47	838.0	23.25	74.10	342.66
NAA @ 200 (mg/kg) + Boron @ 0.1%	1:12.20	6.33	660.67	24.57	90.10	457.33
MH @ 150 (mg/kg) + Boron @ 0.1%	1:12.36	6.40	811.33	23.89	71.40	392.00
SEm (±)	0.80	0.17	57.55	0.51	5.64	57.22
CD (p= 0.05)	2.34	0.49	167.98	1.48	16.64	22.05

Table 2. Mean performances of bottle gourd *Cv*. Pusa Naveen on impact of PGRs,boron and their combinations for TSS (ºBrix) and ascorbic acid (mg/100g)

Treatments	TSS (ºBrix)	Ascorbic acid in(mg/100g)
Control	4.15	11.40
GA3 @ 30 (mg/kg)	5.04	12.77
GA3 @ 50 (mg/kg)	4.59	12.53
NAA @ 100 (mg/kg)	3.85	12.23
NAA @ 150 (mg/kg)	4.85	12.43
NAA @ 200 (mg/kg)	4.48	12.90
MH @ 150 (mg/kg)	4.44	11.97
Boron @ 0.1%	4.70	12.63
GA3 @ 30 (mg/kg) + Boron @ 0.1%	4.48	12.33
GA3 @ 50 (mg/kg) + Boron @ 0.1%	4.52	12.00
NAA @ 100 (mg/kg) + Boron @ 0.1%	4.70	11.30
NAA @ 200 (mg/kg) + Boron @ 0.1%	4.00	11.90
MH @ 150 (mg/kg) + Boron @ 0.1%	4.44	11.93
SEm (±)	0.20	0.42
CD (p= 0.05)	0.60	1.24

number of nodes appearing initial flower. The highest, on the other hand, was obtained with a combination of MH at 150 mg/kg+ Boron @ 0.1%. The role of hormone movement, cell division, respiration, and water metabolism in accelerating blooming could be one of the reasons for the early appearance of the first flower. Hossain et al. [9] made a similar observation with bitter gourd.

The lowermost sex ratio was obtained with the use of GA_3 @ 50 ppm, whereas the highest was noticed in control. The sex ratio may be highly affected by genetics besides environment factors (*e.g.* photoperiod, temperature *etc*.). Change from vegetative growth to generative stages is a complex process regulated by many factors and can be influenced by the use of crop growth regulators. Growth regulators can change the sex ratio and sequence if applied at the 2 or 4 leaf stage, which is the important stage for suppressing or promoting either sex. Dixit et al. [10] reported comparable results in watermelon, Dostogir et al. [11] in bitter gourd, and Ujjwal et al. [12] in tomato. The highest number of fruits per vine was reported in GA3 @ 50 ppm, whereas the lowest was observed in control. Poor pollination, percentage of fruit set, sex ratio, genetic nature, and reaction to varied climatic conditions could all explain the fluctuation in the quantity of fruits per vine. Sure et al. [13] found a similar result in pumpkin, Dixit et al. [10] in watermelon, Dostogir et al. [11] in bitter gourd, Hidayatullah et al. [14] in bottle gourd, and Ujjwal et al. [12] in tomato. The combined application of NAA @ 100 mg/kg+ Boron @ 0.1% produced the most fruit weight, whereas the control produced the least. The combined application of NAA and boron can increase fruit weight due to increased nutrient availability, high nutrient uptake, and photosynthetic rate, all of which boost the fruit output of bottle gourd. Khatoon et al. [15]; Fozia et al. [16] discovered comparable results in bitter gourd. The longest fruit was found in NAA @ 200 mg/kg+ Boron @ 0.1%, which was shown to be significantly superior to the other treatments. The shortest fruit length was discovered in MH at 150 ppm. NAA may be responsible for increasing the activity of enzymes and sugars, resulting in increased fruit length. These findings agree with those of Rafeekher et al. [17] in cucumber and Prabhu and Natarajan [18] in ivy gourd. The maximum diameter of fruit was measured when NAA at 200 mg/kgwas combined with Boron at 0.1%. The lowest diameter of fruit, on the other hand, was discovered in the control. This could be due to increased cell wall permeability, hormonal activity, and photosynthetic activity, all of which contribute to increased fruit diameter. This study supported the findings of Rafeekher *et al*. [17] in cucumber and Fozia et al. [16] in bitter gourd. The greatest yield per vine was found to be non-significant in GA3 @ 50 ppm, however the minimal fruit production per vine was seen in the combination of GA3 @ 30 mg/kg+ Boron @ 0.1%. In comparison to the control for fruit output per vine, there is no significant response to any plant growth regulator or boron. The combination of NAA @ 200 mg/kg+ Boron @ 0.1% produced the highest yield per plot, while the control produced the lowest yield. The increase in yield is related to improved fruit production, improved uptake of hormones and water from the soil, and increased photosynthetic activity due to increased leaf number, which resulted in increased food accumulation per plant. These findings are consistent with those reported in bitter gourd by Marbhal et al. [19]; Fozia et al. [16]. The combination of NAA @ 200 mg/kg+ Boron @ 0.1% produced the highest yield per hectare, while the control produced the lowest yield per hectare. The increase in yield-related features might be attributed to increased soil nutrient and water intake, increased leaf number and area, and increased photosynthetic activity and food buildup. These findings are consistent with those reported in bitter gourd by Marbhal et al. [19]; Fozia et al. [16].

The highest total soluble solid was identified in GA3 at 30 ppm, while the lowest was found in NAA at 100 ppm. This could be due to genetic factors and growth regulators, both of which influence the percentage of total soluble solids in the fruits. Furthermore, it could be owing to the fruit accumulating more reserve components. Shafeek et al. [20] discovered a similar outcome in summer squash. The maximal ascorbic acid level of fruit was determined to be non-significant at 200 mg/kg in NAA. In contrast, the combination of NAA at 100 mg/kg+ Boron @ 0.1% resulted in the lowest ascorbic acid content of fruit.

Based on the findings of this study, it is possible to conclude that GA3 @ 50 mg/kg produced the best results for lowest sex ratio and that the combination of NAA @ 200 mg/kg+ Boron @ 0.1% produced the best results for yield in bottle gourd. As a result, these treatments should be employed to boost bottle gourd output in the Garhwal region.

4. CONCLUSION

The result of the present investigation showed that GA_3 @ 50 mg/kg was registered as the best treatment in terms of vine length (376.13 cm), fruits per vine (6.60), sex ratio (F:M) 1:11.07 and yield per vine (1357.33 g) and NAA @ 200 mg/kg + Boron @ 0.1% with relation to the number of main branches per vine (10.87), length of fruit (24.57 cm), diameter of fruit (90.10 mm), yield per plot (10.29 kg/plot) and yield per hectare (457.33 q) in bottle gourd. However, GA_3 @ 50 mg/kg+ Boron @ 0.1% number of node per vine (24.27), number of node bearing first flower GA_3 50 @ mg/kg(4.20) and NAA @ 150 mg/kg(4.20), weight of fruit NAA @ 100 mg/kg+ Boron @ 0.1% (838.0 g) , total soluble solid GA_3 @ 30 mg/kg(5.04 ºBrix) and NAA @ 200 mg/kg ascorbic acid (12.90 mg/100g). The cultivar (Pusa Naveen) gives better response with the application of GA_3 @ 50 mg/kg for sex expression and NAA @ 200 mg/kg+ Boron @ 0.1% for various growth and yield parameters. It can be recommended to enhance the production of bottle gourd under Garhwal valley of Uttarakhand.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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