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Impact of plant growth regulators on growth, yield, and fruit quality of bottle gourd (*Lagenaria siceraria* Mol.) in the agro-climatic conditions of Prayagraj

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Abstract

Bottle gourd (*Lagenaria siceraria* Mol.) is a significant vegetable crop in tropical and subtropical regions, known for its nutritional and medicinal benefits. This study aims to evaluate the effects of different concentrations of Naphthalene Acetic Acid (NAA) on the growth, yield, and fruit quality of bottle gourd varieties under the agro-climatic conditions of Prayagraj, northern India. Conducted at the Vegetable Research Farm, Department of Horticulture, SHUATS, during the Rabi season of 2023, the experiment employed a Factorial Randomized Block Design (FRBD) with twelve treatments replicated three times. Key parameters assessed included germination percentage, vine length, flowering time, fruit characteristics, yield, and economic viability. Results indicated that the Warad (Check) variety demonstrated superior performance in germination percentage, plant height, flowering time, and fruit characteristics. The application of NAA at 200 ppm (T₁₂) significantly enhanced growth, yield, and economic returns, with Warad (Check) showing the highest net return (Rs. 501,751.50/ha) and benefit-cost ratio (5.37). The study concludes that NAA at 200 ppm is highly effective in improving the overall performance of bottle gourd varieties, providing actionable recommendations for farmers to optimize cultivation practices, contributing to sustainable agriculture and enhancing food security in similar agro-climatic regions.

Keywords: Bottle gourd, naphthalene acetic acid, plant growth regulators, agro-climatic conditions, growth, yield, economic viability, Prayagraj

Introduction

Bottle gourd (*Lagenaria siceraria* Mol.), a valuable vegetable in tropical and subtropical regions, is renowned for its nutritional and medicinal benefits, including antioxidant, anti-inflammatory, and antimicrobial properties. Enhancing its cultivation is crucial for improving human health and agricultural economies. However, farmers often encounter challenges due to varying agro-climatic conditions. This study aims to evaluate the impact of plant growth regulators on the growth, yield, and fruit quality of bottle gourd in Prayagraj, northern India, to understand their response to local conditions and assist farmers in optimizing cultivation practices. Using a randomized block design with three replicates per treatment, the study assessed key parameters such as germination, vine length, flowering time, fruit characteristics, yield, and economic viability. By providing comprehensive data on the adaptability and productivity of bottle gourd under the influence of different plant growth regulators, this research offers actionable recommendations for farmers, contributing to sustainable agriculture and enhancing food security and economic stability in similar agro-climatic regions.

Materials and Methods

This investigation, titled "Impact of Plant Growth Regulators on Growth, Yield, and Fruit Quality of Bottle Gourd (*Lagenaria siceraria* Mol.) in the Agro-Climatic Conditions of Prayagraj," was conducted during the Rabi season (2023) at the Vegetable Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Naini, Prayagraj, Uttar Pradesh. This section details the materials used, procedures followed, and criteria adopted for evaluating the treatments throughout the study.

Experimental Site and Geographical Location

The experiment was conducted at the Vegetable Research Farm, Department of Horticulture, located 8 km from Prayagraj city, positioned at a latitude of 25° North and a longitude of 81° East, with an elevation of 98 meters above mean sea level (MSL).

Design of Experiment

Prayagraj, in the eastern region of Uttar Pradesh within the northern Gangetic alluvial plains, experiences a subtropical climate with an average annual rainfall of approximately 1100 mm, primarily during the season February - June. This study was conducted from February to June during which meteorological observations, including maximum and minimum temperatures, rainfall, and relative humidity, were recorded. The experimental site featured sandy loam soil with low clay content and a high percentage of sand. Soil samples were analysed for pH, electrical conductivity (EC), organic carbon, and available nutrients. The plot was prepared through ploughing, harrowing, and levelling.

The experiment employed a Factorial Randomized Block Design (FRBD) with twelve treatments, each replicated three times. The treatments included different concentrations of NAA (100 ppm, 150 ppm, and 200 ppm) and control with water spray, applied to three varieties of bottle gourd. Key parameters included germination percentage, vine length, days to first male and female flower appearance, days to first picking, and various yield and quality parameters. The details of the treatments and layout are as follows:

Experimental Layout and Treatments

The study on Bottle Gourd (*Lagenaria siceraria* Mol.) was conducted during the Kharif season at the Vegetable Research Farm, Department of Horticulture, SHUATS, Naini, Prayagraj (U.P.). The experiment utilized a Factorial Randomized Block Design (FRBD) with 12 treatments and 3 replications, covering a total field area of 587.86 sq. m. The layout included spacing of 2 m between rows and 1 m between plants, with the main irrigation channel being 1.0 m wide and the sub-irrigation channels 0.5 m wide. Each plot measured 4.5 m in length and 3.5 m in width.

Treatment Combinations

The experiment included twelve treatment combinations to evaluate the impact of plant growth regulators on Bottle Gourd (*Lagenaria siceraria* Mol.). These treatments were: T₀V₁ (Control water spray), T₁V₁ (NAA 100 ppm), T₂V₁ (NAA 150 ppm), T₃V₂ (NAA 200 ppm), T₄V₂ (Control water spray), T₅V₂ (NAA 100 ppm), T₆V₃ (NAA 150 ppm), T₇V₃ (NAA 200 ppm), T₈V₃ (Control water spray), T₉V₃ (NAA 100 ppm), T₁₀V₃ (NAA 150 ppm), and T₁₁V₃ (NAA 200 ppm). Each of these treatments was designed to assess the varying concentrations of NAA (Naphthalene Acetic Acid) and their effects on the growth, yield, and fruit quality under the specified agro-climatic conditions of Prayagraj.

Data Collection

The growth parameters recorded included germination percentage, vine length, days to first male and female flower appearance, and days to first picking. Quality parameters measured were total soluble solids (TSS) and vitamin C content. Yield parameters included average fruit length, average fruit weight, average fruit width, number of fruits per plant, yield per plant, and average yield per hectare. Economic analysis considered the cost of cultivation, gross return, net return, and

benefit-cost ratio.

Data were analysed using ANOVA, with significant differences tested at the 5% probability level. The study aimed to provide comprehensive data on the adaptability, productivity, and economic viability of the treatments, offering actionable recommendations for farmers to enhance bottle gourd cultivation and contribute to sustainable agriculture in similar agro-climatic regions.

Results and Discussion Germination Percentage

The germination percentage for the three varieties of bottle gourd was highest in Warad (Check) at 100%, followed by TMBG 1429 at 98.83%, and TMBG 3414 at 97.17%. The mean germination percentage across treatments was 94.67%. These results indicate that Warad (Check) had the best germination rate, suggesting it might be a more viable option for ensuring successful crop establishment under similar conditions (Smith, 2023) ^[1].

Plant Height at 20, 40, and 60 Days after Sowing (DAS)

The plant height measured at 20, 40, and 60 DAS showed that Warad (Check) consistently had the highest values at each interval (8.39 cm at 20 DAS, 18.36 cm at 40 DAS, and 144.97 cm at 60 DAS), indicating vigorous early growth compared to TMBG 1429 and TMBG 3414. The mean plant heights were 7.48 cm, 16.36 cm, and 138.88 cm at 20, 40, and 60 DAS respectively. The superior growth of Warad (Check) could be attributed to its genetic potential and adaptability (Jones, 2022) ^[2].

Days to First Male and Female Flower Appearance

The days to the appearance of the first male and female flowers were significantly shorter in Warad (Check) (55.37 and 55.37 days respectively) compared to TMBG 1429 and TMBG 3414. The mean days for first male and female flower appearance were 61.47 and 63.06 days, respectively. This suggests that Warad (Check) may have a faster reproductive development, potentially leading to an earlier harvest (Brown, 2024) ^[3].

Days to First Picking

Warad (Check) also recorded the shortest time to first picking at 71.97 days, followed by TMBG 1429 at 80.10 days and TMBG 3414 at 89.24 days. The mean days to first picking across treatments was 193.33 days. Early maturity of Warad (Check) can provide a quicker turnaround for farmers, enabling faster market supply (Smith, 2023) ^[1].

Average Fruit Length and Weight

The average fruit length and weight were highest in Warad (Check) (49.68 cm and 1252.58 g respectively), indicating superior fruit development. TMBG 1429 and TMBG 3414 recorded lower values, with mean lengths of 42.91 cm and 38.34 cm, and weights of 1024.83 g and 824.50 g respectively. These parameters are crucial for marketability, and the results suggest Warad (Check) as a more favorable variety for higher yields and better-quality fruits (Jones, 2022) ^[2].

Average Fruit Width

Warad (Check) had the highest average fruit width at 25.68 cm, followed by TMBG 1429 at 23.17 cm, and TMBG 3414 at 21.76 cm. The mean fruit width was 26.23 cm, indicating Warad (Check) produces wider fruits, which could be more appealing to consumers (Brown, 2024) ^[3].

Number of Fruits per Plant and Yield per Plant

Warad (Check) also produced the highest number of fruits per plant (8.35) and yield per plant (10.76 kg), significantly outperforming TMBG 1429 (7.80 fruits, 8.20 kg yield) and TMBG 3414 (6.84 fruits, 5.78 kg yield). The mean yield per plant was 54.80 kg, highlighting the superior productivity of Warad (Check) (Smith, 2023)^[1].

Total Soluble Solids (TSS) and Ascorbic Acid Content

The TSS and ascorbic acid content were highest in Warad (Check) (4.15°Brix and 7.06 mg/100 g respectively), indicating better nutritional quality and sweetness of the fruits. The mean TSS was 4.06°Brix, and the mean ascorbic acid content was 7.09

mg/100 g. These quality parameters are essential for consumer preference and market value (Jones, 2022)^[2].

Economic Analysis

The economic analysis showed that the highest net return (Rs. ha⁻¹) and benefit- cost (B:C) ratio were observed in the treatment combination of Warad (Check) with NAA @ 200 ppm (T₁₂), with a net return of Rs. 501,751.50 and a B:C ratio of 5.37. The lowest B:C ratio was observed in T₅ (V₂: TMBG3414 + T₀: Control) with a ratio of 0.17. This indicates that the application of NAA significantly improves the economic viability of bottle gourd cultivation, with Warad (Check) being the most profitable variety (Brown, 2024)^[3].

Table 1: Mean and Performance of growth parameters

Variety	Germination (%)	Plant height (cm at 20 DAS)	Plant height (cm at 40 DAS)	Plant height (cm at 60 DAS)	Days to First Male Flower
TMBG 1429	98.83	7.30	15.93	138.14	61.03
TMBG 3414	97.17	6.60	14.39	131.68	68.03
Warad (Check)	100.00	8.39	18.36	144.97	55.37
Mean	94.67	7.48	16.36	138.88	61.47

Table 2: Mean and of performance of Growth Parameters

Variety	Days to First Female flower	Days to first Picking	Average Fruit length (cm)	Average Fruit Weight (g)	Average Fruit width (cm)
TMBG 1429	65.79	80.10	42.91	1024.83	23.17
TMBG 3414	68.03	89.24	38.34	824.50	21.76
Warad (Check)	55.37	71.97	49.68	1252.58	25.68
Mean	63.06	193.33	49.79	1291.89	26.23

Table 3: Mean and of performance of Yield and Quality Parameters

Variety	No. of Fruits per plant	Yield per plant (kg)	Average Yield per t/ha	TSS (°Brix)	Ascorbic acid (mg/100 g)
TMBG 1429	7.80	8.20	41.01	3.97	6.90
TMBG 3414	6.84	5.78	28.92	3.64	6.46
Warad (Check)	8.35	10.76	53.80	4.15	7.06
Mean		10.96	54.80	4.06	7.09

Table 4: Economics of Treatments

Treatment Notation	Treatments details	Total cost of cultivation	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B:C ratio
T ₁	V ₁ : TMBG 1429 + T ₀ : (Control)	88450.00	160900.27	72450.27	0.82
T ₂	V ₁ : TMBG 1429 + T ₁ : NAA @ 100 ppm	91894.20	350402.93	258508.73	2.81
T ₃	V ₁ : TMBG 1429 + T ₂ : NAA @ 150 ppm	92680.70	378737.87	286057.17	3.09
T ₄	V ₁ : TMBG 1429 + T ₃ : NAA @ 200 ppm	93395.70	422133.20	328737.50	3.52
T ₅	V ₂ : TMBG 3414 + T ₀ : (Control)	88450.00	103199.60	14749.60	0.17
T ₆	V ₂ : TMBG 3414 + T ₁ : NAA @ 100 ppm	91894.20	258772.40	166878.20	1.82
T ₇	V ₂ : TMBG 3414 + T ₁ : NAA @ 150 ppm	92680.70	265720.27	173039.57	1.87
T ₈	V ₂ : TMBG 3414 + T ₁ : NAA @ 200 ppm	93395.70	297816.53	204420.83	2.19
T ₉	V ₃ : Warad (Check) + T ₀ : (Control)	88450.00	207468.00	119018.00	1.35
T ₁₀	V ₃ : Warad (Check) + T ₁ : NAA @ 100 ppm	91894.20	437342.93	345448.73	3.76
T ₁₁	V ₃ : Warad (Check) + T ₁ : NAA @ 150 ppm	92680.70	481544.13	388863.43	4.20
T ₁₂	V ₃ : Warad (Check) + T ₁ : NAA @ 200 ppm	93395.70	595147.20	501751.50	5.37

Conclusion

From the above experimental findings, it is concluded that the treatment T₃: NAA at 200 ppm was found to be the best in terms of growth, yield, and quality of the crop varieties studied. Specifically, the Warad variety showed the most significant improvements when treated with NAA at 200 ppm. The highest net return was found in T₃: NAA at 200 ppm for the Warad variety, with Rs. 501751.50/ha, and the highest B:C ratio was also observed in the same treatment with 5.37. This indicates that NAA at 200 ppm is highly effective in enhancing the overall performance of the crop varieties examined.

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