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Effect of genotype, planting density, and NPK levels on seedless cucumber yield, quality, and profitability under protected cultivation

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Abstract
The present study was conducted from 2017 to 2019 at the Vegetable Research Farm, SHUATS, Prayagraj, Allahabad, U.P., with three replications. The experiment included a total of twenty-seven treatment combinations, consisting of three cucumber cultivars: Pant Parthenocarpic Cucumber-2 (V1), Pant Parthenocarpic Cucumber-3 (V2), and Hilton (V3); three plant spacings: 60 × 30 cm (P1), 60 × 40 cm (P2), and 60 × 50 cm (P3); and three NPK fertilizer doses: 20:10:22 kg/1000 m² (D1), 25:15:27 kg/1000 m² (D2), and 30:20:32 kg/1000 m² (D3). Fertilizers were applied twice a week, and the same treatments were maintained across both years. The results indicated that all treatments and their combinations significantly affected growth, yield, fruit quality, and the benefit-cost (B:C) ratio in both years. Among the cultivars, Pant Parthenocarpic Cucumber-3 (V2) was found to be statistically superior, enhancing vine length (2.73 m), stem girth (0.80 cm), leaf area (412.34 cm²), internodal distance (8.38 cm), and reducing the days required for first flower bud initiation (42.14 DAS) and first fruit harvest (55.42 DAS). V2 also produced the highest number of fruits per vine (21.89), minimum unmarketable fruits per plant (1.46), average fruit weight (116.41 g), fruit length (18.35 cm), and fruit width (3.45 cm), ultimately resulting in the maximum yield per vine (2.82 kg/plant) on pooled analysis. Regarding plant spacing, the 60 × 50 cm spacing (P3) was significantly superior for vegetative growth, yield per plant, and fruit quality, except for yield per square meter, which was highest in 60 × 30 cm spacing (P1) and lowest in P3 during both years. Concerning fertilizer application, manual application to the plant root zone (D3) resulted in superior performance compared to lower doses (D1 and D2). Maximum fruits per vine, average fruit weight, yield per vine, and yield per square meter were observed with the highest NPK dose (D3). Furthermore, the highest leaf nutrient content—total nitrogen (3.66%), phosphorus (0.83%), and potassium (2.44%) was recorded under D3, while soil nutrient residues after harvest were lowest with the maximum NPK dose in both years.

Keywords: Parthenocarpic cucumber, dose of fertilizers, spacing, polyhouse, growth, yield, quality and BC Ratio.

Introduction
Cucumber (*Cucumis sativus* L.) is a widely cultivated vegetable belonging to the Cucurbitaceae family, which also includes melons, pumpkins, and squash. Known for its high water content, mild flavor, and nutritional benefits, cucumber is primarily consumed fresh in salads, pickles, and various culinary preparations. Cucumber is one of the most important vegetable crops of the Cucurbitaceace family and having a chromosome number, 2n = 14. As a vegetable crop cucumber has great economic importance. The immature fruit of cucumber are use as salad and for making pickles, pahari rayata and brined on commercial scale. (Bairagi *et al* 2013) [2]. The global production of cucumber is 71.36 million tons (FAOSTAT 2014) [3] and commercially cultivated in countries like China, India, Turkey, Iran, Japan, Europe and United States. In the world more than 55 countries adopted protected cultivation technology; China has the largest area of 2.7 mha under protected cultivation Kacira. The total area of protected cultivation in India is approx 30,000 ha. Contributes 0.23% of the total area under the horticulture crop cultivation in India at and of 11th five year plan (Shweta *et al*., 2014) [7]. The total area of

cucumber growing In India 78,000 hectares with an annual production of 11.42 lakh MT (National Horticulture Board 2016-17) [5]. The main areas of cucumber cultivation are river beds of Yamuna, Ganges and Narmada in North and Kaveri, Krishna and Godavari in South (Singh).

Materials and Methods

The present study was conducted in the river basins of the Ganga and Yamuna, located at 28°0.87′ N latitude and 81°0.15′ E longitude, with an elevation of 98 m above mean sea level. The region receives an average annual rainfall of 1013.4 mm. The polyhouse used in the experiment was covered with ultraviolet-stabilized low-density polyethylene sheets of 200 µm thickness. The experiment involved a total of twenty-seven treatment combinations, consisting of three levels of plant spacing- 60×30 cm (P1), 60×40 cm (P2), and 60×50 cm (P3); three cucumber cultivars—Pant Parthenocarpic Cucumber-2 (V1), Pant Parthenocarpic Cucumber-3 (V2), and Hilton (V3); and three fertilizer doses—D1 (20:10:22), D2 (25:15:27), and D3 (30:20:32 kg/1000 sq.m). The treatments were arranged in a factorial randomized block design (RBD) with three replications.

Observations were recorded for fifteen parameters encompassing vegetative growth, yield, and quality-related traits. The economics of each treatment were evaluated based on the prevailing market prices of inputs and produce. All recorded data were subjected to statistical analysis using analysis of variance (ANOVA) appropriate for a factorial RBD.

Results and Discussion

The results indicated that the cultivar had a significant effect on the plant height and stem girth of cucumber under polyhouse conditions. The highest plant height (2.73 m) and stem girth (0.80 cm) were observed in Pant Parthenocarpic Cucumber-3, which can be attributed to the genetic characteristics of the cultivar. Moreover, the polyhouse environment provided favourable conditions that promoted the growth of the plants by modifying the natural environment and improving the surrounding microclimatic conditions. Plant geometry also significantly influenced cucumber growth. Plants grown at wider spacing (60 × 50 cm) exhibited greater plant height (2.74 m) and stem girth (0.79 cm) compared to those at closer spacing (60 × 30 cm), likely due to the increased availability of space for growth.

The present study showed that cucumber growth, yield, and fruit quality during the winter season were significantly influenced by cultivar, plant spacing, and fertilizer dose. Maximum vine length (3.04 m) was observed in Pant Parthenocarpic Cucumber-3 (V2) grown at 60 × 50 cm spacing (P3) with the highest fertilizer dose (30:20:32 kg NPK, D3) in treatment T_18, indicating that optimal growth is achieved through the combined effect of these factors. Days to first fruit harvest were significantly reduced by the same factors. Pant Parthenocarpic Cucumber-3 required the fewest days to harvest (55.42 DAS), with the earliest harvest recorded in the combined T_18 treatment (52.40 DAS). Wider spacing and higher fertilizer doses further accelerated fruiting. The number of fruits per plant and average fruit weight were highest in Pant Parthenocarpic Cucumber-3, with 21.89 fruits per plant and 116.41 g per fruit. Wider spacing (P3) and higher fertilizer application (D3) enhanced fruit set and size, and the interaction of all three factors in T_18 produced the best overall results. Yield per plant and per unit area followed a similar trend. Pant Parthenocarpic Cucumber-3 yielded 2.82 kg per plant, which increased to 3.20 kg per vine under the T_18 combination. Wider spacing and higher fertilizer doses contributed to improved yield, highlighting the importance of plant density and nutrient management. Fruit quality, including length, width, moisture content, TSS, and organoleptic acceptance, was significantly improved in Pant Parthenocarpic Cucumber-3. Maximum fruit length (19.50 cm), width (3.46 cm), moisture content (95.65%), and organoleptic score (8.75) were recorded under T_18. Fruit volume and specific gravity were also highest in this cultivar, while fruit color remained a reliable indicator of freshness.

Overall, Pant Parthenocarpic Cucumber-3 with 60 × 50 cm spacing and highest fertilizer dose consistently showed superior growth, yield, and quality. These results emphasize the effectiveness of combining optimal cultivar selection, plant geometry, and nutrient management for maximizing cucumber productivity under polyhouse winter conditions.

Table 1: Treatment combinations for enhancing growth and yield of cucumber under protected cultivation

Treatments	Height of plant (m)	Girth of stem (cm)	First fruits picking (DAS)	Yield per plants (Kg)	TSS (^{0}Barix)	Moisture%	Specific Gravity	Organoleptic acceptance	Fruit length (cm)	fruit width (cm)	B:C Ratio
T_1	2.59	0.73	58.25	2.35	3.15	94.25	0.90	7.35	15.30	3.32	2.84
T_2	2.73	0.75	57.60	2.40	3.17	94.60	0.91	7.85	15.70	3.35	2.98
T_3	2.61	0.77	57.40	2.50	3.20	94.75	0.92	7.30	16.20	3.39	3.05
T_4	2.71	0.77	58.10	2.45	3.20	94.50	0.91	7.85	15.90	3.37	2.80
T_5	2.75	0.76	57.30	2.60	3.23	94.00	0.94	7.20	16.60	3.34	3.02
T_6	2.70	0.78	57.15	2.70	3.23	93.65	0.94	7.40	17.00	3.43	3.12
T_7	2.73	0.77	57.15	2.60	3.24	94.40	0.92	7.30	16.40	3.41	2.87
T_8	2.71	0.79	56.90	2.80	3.27	93.60	0.95	7.20	17.00	3.44	3.03
T_9	2.65	0.79	56.30	2.80	3.31	93.80	0.95	7.75	17.30	3.47	3.13
T_{10}	2.56	0.75	57.10	2.55	3.26	94.60	0.91	7.25	16.85	3.40	3.05
T_{11}	2.73	0.78	56.00	2.65	3.31	94.75	0.91	7.35	17.50	3.41	3.21
T_{12}	2.65	0.77	55.80	2.70	3.34	95.65	0.92	7.35	17.90	3.45	3.35
T_{13}	2.61	0.79	56.70	2.65	3.37	94.60	0.91	7.20	18.10	3.44	3.17
T_{14}	2.73	0.80	56.10	2.80	3.42	94.10	0.94	7.60	18.50	3.41	3.31
T_{15}	2.64	0.81	55.50	3.00	3.44	94.45	0.94	7.20	18.70	3.47	3.40
T_{16}	2.72	0.82	55.20	2.85	3.47	93.70	0.92	7.15	18.80	3.45	3.19
T_{17}	2.90	0.83	54.00	3.00	3.53	94.55	0.95	7.85	19.30	3.50	3.36
T_{18}	3.04	0.85	52.40	3.20	3.57	94.75	0.95	8.75	19.50	3.55	3.73
T_19	2.71	0.78	58.00	2.45	3.24	94.15	0.91	7.25	16.50	3.35	2.93
T_20	2.72	0.74	57.50	2.65	3.27	93.65	0.91	7.30	17.00	3.35	3.10

$T_2$1	2.80	0.77	57.30	2.75	3.28	94.55	0.92	7.25	17.20	3.40	3.18
$T_2$2	2.72	0.78	57.90	2.85	3.31	93.70	0.91	7.10	17.50	3.39	2.90
$T_2$3	2.71	0.77	57.10	2.65	3.33	94.25	0.94	7.00	18.00	3.41	3.12
$T_2$4	2.71	0.78	56.90	2.85	3.36	93.60	0.94	7.20	18.30	3.44	3.21
$T_2$5	2.76	0.81	57.05	2.75	3.38	93.70	0.92	7.25	18.30	3.42	2.99
$T_2$6	2.72	0.81	56.50	2.85	3.42	94.45	0.95	7.05	18.50	3.45	3.14
$T_2$7	2.77	0.81	55.90	2.80	3.44	93.05	0.95	7.20	18.70	3.49	3.21
CD value at 5%	0.010	0.013	0.431	0.083	0.101	0.238	0.017	0.365	0.141	0.010	

Conclusion

The findings of this study clearly demonstrate that the treatment $T_1$8, which involves the Pant Parthenocarpic-3 variety (V2) combined with a fertilizer dose of 30:20:32 kg/ha and a planting spacing of 60 × 50 cm, outperformed all other treatments in terms of plant growth, flowering, yield, and quality parameters. The results suggest that maintaining a higher plant population through a spacing of 60 × 50 cm, along with the specified fertilizer regime, is optimal for enhancing most growth and yield characteristics. Among the cucumber varieties evaluated, Pant Parthenocarpic-3 (V2) showed superior productivity under protected polyhouse conditions compared to Hilton and Pant Parthenocarpic-2. Overall, the integrated combination of the V2 variety, D3 fertilizer level, and P3 spacing (V2+D3+P3) proved to be the most effective strategy for achieving the highest yield and maximizing the benefit-cost ratio.

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