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Effect of humic acid and micronutrients on vegetative growth of Cucumber (*Cucumis sativus* L.) c.v. Pusa Parthenocarpic cucumber -6 under protected conditions

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Abstract

For sustainable enhancement of crop growth under protected environments, the integrated application of humic acid and micronutrients can significantly improve vegetative growth characteristics of cucumber. In this context, a field experiment was conducted with Cucumber Var. Pusa Parthenocarpic Cucumber -6 at the Research Farm of the Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur U.P during the summer seasons 2025 with the objective to study the effect of humic acid and micronutrients on vegetative growth under protected conditions. The experiment was laid out in a Randomized Block Design (RBD) with seven treatments and three replications. The results revealed that the treatment, T₇ [RDF + humic acid (10 kg ha⁻¹ as soil application) + humic acid (0.1% foliar spray) + micronutrient mixture foliar spray (0.4% Zn + 0.2% B + 0.4% Mn) recorded the highest value of all the growth parameters. The plots deliver with this treatment demonstrated maximum vine length (44.14 cm, 180.99 cm, 304.34 cm at 25,40 and 55 DAT), number of branches per plant (1.64, 6.13, 14.21 at 25,40,55 DAT), leaf area (496.92 cm²), days taken to earlier flowering (26.07 days) and earlier harvesting (34.63 days). These findings indicate that the combined application of RDF, humic acid, and micronutrients can substantially enhance growth of cucumber under protected cultivation.

Keywords: Cucumber, humic acid, micronutrients, vegetative growth

Introduction

Cucumber (*Cucumis sativus* L.) is an economically important vegetable crop belonging to the family Cucurbitaceae and is widely cultivated in tropical and subtropical regions of the world. India is considered one of its primary centres of origin (Harlan, 1975) ^[1], while the occurrence of *Cucumis sativus* var. *hardwickii* indicates Northern India as its native region (Pursglove, 1969). Owing to its short crop duration, high productivity, and nutritional value, cucumber occupies an important place among vegetable crops. The fruits contain high moisture content along with carbohydrates, proteins, minerals, dietary fibre, calcium, iron, and vitamin C (Bhattacharya *et al.*, 2015) ^[3]. According to the National Horticulture Board (2023), cucumber and gherkin are cultivated over 138.54 thousand ha. total production 20.14 lakh tonnes and average productivity 14.36 to 15.32 tonnes per hectare.

Protected cultivation has emerged as an effective technology for improving crop productivity, quality, and profitability by providing a favourable microclimate and enhancing resource-use efficiency (Mishra *et al.*, 2010) ^[6]. Cucumber is particularly suitable for polyhouse cultivation because of its rapid growth, continuous fruiting habit, and high market demand (Ameta *et al.*, 2019;) ^[4]. However, intensive use of chemical fertilizers has raised concerns regarding nutrient imbalance, soil degradation, and environmental sustainability, necessitating the adoption of integrated nutrient management approaches.

Humic acid, a major component of soil organic matter, improves nutrient availability, root development, microbial activity, and physiological processes such as photosynthesis and enzyme activity (Larcher, 2003; Chen *et al.*, 2017; Nardi *et al.*, 2021) ^[8, 10, 12]. Similarly, micronutrients such as boron, zinc, and manganese play vital roles in plant growth and metabolism (Mohsen, 2013;) ^[14]. However, information on their combined application under protected cultivation remains limited. Therefore, the present investigation was undertaken to evaluate the effect of

humic acid and micronutrients on the vegetative growth of cucumber cv. Pusa Seedless Cucumber-6 under protected conditions.

Materials and Methods

Experimental site and location

The experiment was undertaken during the summer cropping seasons of 2025 at the Research Farm, Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh. Kanpur is situated in the Central Plain Zone of Uttar Pradesh, but the ICAR's agroclimatic zones place it in the Upper Gangetic Plain Zone. It is located 125.91 meters above mean sea level (MSL). It is located geographically at altitude range between 25.28° to 28.50° North and longitude range between 79.31° to 84.34° East.

The primary objective of the investigation was to assess the effect of humic acid and micronutrient on vegetative growth of cucumber under protected conditions the experimental design adopted for this research was a Randomized Block Design (RBD) featuring Seven distinct treatments, each with three replications. The treatments included T₁ (RDF control), T₂ (RDF + humic acid 10 kg/ha (soil application), T₃ (RDF + humic acid 0.1% (foliar spray)), T₄ (RDF + humic acid 10 kg/ha + humic acid 0.1% (foliar spray)), T₅ (RDF + humic acid 10 kg/ha + micronutrients mixture (foliar spray)), T₆ (RDF + humic acid 0.1% + micronutrients mixture (foliar spray), and T₇ (RDF + humic acid 10 kg/ha + humic acid 0.1% + micronutrients mixture foliar spray (0.4% Zn + 0.2% B + 0.4% Mn).

Crop details and cultural practices

Cucumber variety – Pusa Seedless Cucumber-6 (also known as PPC-6) is a high-yielding, extra-early parthenocarpic gynoecious cucumber developed by ICAR-IARI. It produces uniform, glossy, and non-bitter fruits without pollination. It is highly prized for winter greenhouse cultivation in India. Initially, seedlings were cultivated within a controlled environment polyhouse for approximately 21-25 days before transplanting them in the field. Subsequently, during the bed preparation phase, precise quantities of recommended dose of fertilizer were methodically incorporated into the soil of designated plots, adhering to the treatment-specific combinations. Furthermore, to meet the nutritional requirements of the cucumber, nitrogen, phosphorus, and potassium were administered in the form of urea (46% N), diammonium phosphate (46% P₂O₅), and muriate of potash (60% K₂O), respectively, in accordance with the treatment protocols. Vigorous and uniform seedlings, aged around four weeks and characterized by the presence of 2-3 leaves and an average height ranging between 10-15 cm, were transplanted into meticulously prepared experimental plots. These seedlings were spaced at intervals of 90 cm × 60 cm. Subsequently, was used for the study.

As per treatments soil application of humic acid was applied through drenching after transplanting and foliar spray of humic acid was applied after 25 days, whereas foliar spray of micronutrient mixture was applied 40 days after transplanting. All the cultural practices including irrigation and hoeing were carried out as per the standard commercial procedures. Spraying for pests and diseases were applied whenever it appeared necessary throughout the growing season. Plants were vertically trained with plastic ropes. Observations were recorded on five randomly selected plants per replication vine length (cm), number of branches per plant, leaf area (cm²), earlier flowering and early harvesting. The data obtained were subjected to statistical analysis and the results have been documented and presented in tabular form.

Results and Discussion

The data recorded on vegetative parameters clearly indicated that the vine length (cm), number of branches per plant, leaf area (cm²), earlier flowering and early harvesting. were significantly influenced by the humic acid and micronutrients practices.

Vine length (cm)

Table 1 and Figure present empirical data elucidating the influence of humic acid and micronutrients on Vine length. At 25 days after transplantation (DAT), it was observed that the application of T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) resulted in the maximum vine length (44.14 cm). In contrast, T₁ Control exhibited the lowest vine length (34.87 cm). Upon reaching the 40 DAT T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) maintained its supremacy with maximum vine length of (180.99 cm). Conversely T₁ Control continued to demonstrate the minimum vine length (110.76 cm). Upon reaching at 55 DAT, the maximum vine length in T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) valued at (304.34 cm). meanwhile, T₁ control exhibited the minimum vine length at this stage, registering values of (210.33 cm) respectively. The superior performance of T₇ may be attributed to in improving nutrient availability, root development, nutrient uptake, and physiological activities, leading to vigorous vegetative growth. As well as humic substances are known to stimulate cell division and elongation, while micronutrients play essential roles in enzymatic and metabolic processes. The findings suggest that integrated application of humic acid and the synergistic effect of humic acid and micronutrients micronutrients along with recommended fertilizer doses promotes vine elongation and overall crop growth compared to the untreated control. Similar findings were reported by Anjanappa *et al.* (2012) [5], Pradhan *et al.* (2018) [18].

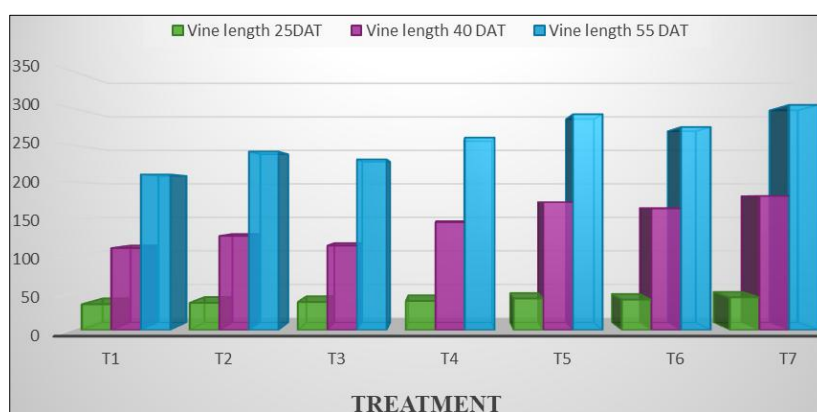


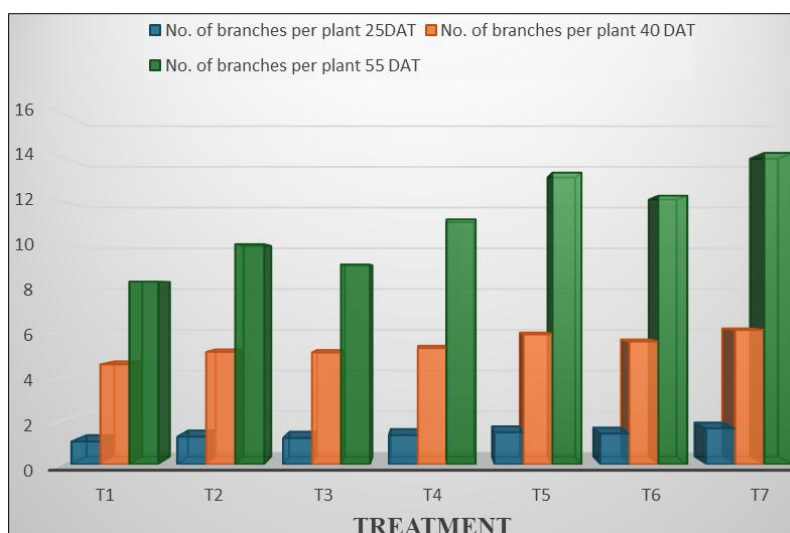
Table 1: Effect humic acid and micronutrients on vine length(cm) in cucumber

Treatment Notation	Treatments	Vine length (cm)		
		25 DAT	40 DAT	55 DAT
T ₁	RDF (control)	34.87	110.76	210.33
T ₂	RDF + humic acid 10 kg/ha (soil application)	36.80	127.22	241.33
T ₃	RDF + humic acid 0.1% (foliar spray)	37.87	114.10	230.67
T ₄	RDF + humic acid 10 kg/ha +humic acid 0.1% (foliar spray)	39.27	145.68	260.12
T ₅	RDF + humic acid 10kg/ha+ micronutrients mixture (foliar spray)	42.53	172.88	291.67
T ₆	RDF + humic acid 0.1%+micronutrients mixture (foliar spray)	41.07	164.44	274.42
T ₇	RDF + humic acid 10 kg/ha + humic acid 0.1% +micronutrients mixture (foliar spray)	44.14	180.99	304.34
SE(m)±		0.97	1.97	3.057
C.D (P=0.05)		3.051	6.15	9.52

Number of branches per plant

Table 2 and Figure present empirical data elucidating the influence of humic acid and micronutrients on Number of branches per plant at 25 days after transplantation (DAT), it was observed that the application of T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) resulted in the highest number of branches per plant (1.64). While T₁ (Control) exhibited the minimum Number of branches per plant (1.04). Moving forward to the 40 DAT T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) maintained its supremacy with maximum Number of branches per plant of (6.13). Conversely T₁ Control continued to demonstrate the least Number

of branches per plant (4.56). Upon reaching at 55 DAT, the maximum Number of branches per plant in T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) valued at (14.21). Meanwhile, T₁ control exhibited the minimum Number of branches per plant at this stage, registering values of (8.34) respectively. The improved branching under T₇ may be attributed to enhanced nutrient availability, root growth, photosynthetic activity, and metabolic processes promoted by humic acid and micronutrients. Similar results were reported by Narayanamma *et al.* (2010) ^[16], Anjanappa *et al.* (2012) ^[5], Kanaujia and Daniel (2016) ^[26], Pradhan *et al.* (2018) ^[18], and Singh *et al.* (2020) ^[20].

**Table 2:** Effect humic acid and micronutrients on No. of branches per plant in cucumber

Treatment Notation	Treatments	No of primary branches		
		25 DAT	40 DAT	55 DAT
T ₁	RDF (control)	1.04	4.56	8.34
T ₂	RDF + humic acid 10 kg/ha (soil application)	1.26	5.13	10.05
T ₃	RDF + humic acid 0.1% (foliar spray)	1.2	5.1	9.12
T ₄	RDF + humic acid 10 kg/ha +humic acid 0.1% (foliar spray)	1.33	5.3	11.18
T ₅	RDF + humic acid 10kg/ha+ micronutrients mixture (foliar spray)	1.46	5.93	13.31
T ₆	RDF + humic acid 0.1%+micronutrients mixture (foliar spray)	1.40	5.6	12.26
T ₇	RDF + humic acid 10 kg/ha + humic acid 0.1% +micronutrients mixture (foliar spray)	1.64	6.13	14.21
SE(m) ±		0.06	0.13	0.32
C.D. (P=0.05)		0.20	0.40	1.02

Days taken to first flowering

Days to first flowering were significantly influenced by the application of humic acid and micronutrients is depicted in Table 3 and figure. The earliest flowering was recorded in T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) resulted in (26.07 days), whereas the

maximum days to flowering were observed in the Control (T₁) (29.12 days). Treatment T₇ induced flowering 3.05 days earlier and reduced the time to first flowering by 10.47% over the control. The earliness in flowering may be attributed to improved nutrient uptake, root development, and enhanced metabolic activity promoted by humic acid and micronutrients. Similar

findings were reported by Olfati *et al.* (2010) ^[25], El-Shabrawy *et al.* (2010), and Hanafy *et al.* (2024). Days to first harvest: Table 4 and Figure present empirical data elucidating the influence of humic acid and micronutrients on days to first harvest from days after transplantation (DAT), it was observed that the Days to first harvest were significantly reduced by the application of humic acid and micronutrients. The earliest harvest was recorded in T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients)

(34.63 days), while the maximum days to first harvest were observed in the Control (T₁). Treatment T₇ enabled harvesting 4.41 days earlier and reduced the time to first harvest by 11.29% over the control. The earliness in harvesting may be attributed to improved nutrient uptake, enhanced vegetative growth, and better physiological activities, leading to early flowering and fruit maturity. These findings are in agreement with Lakhan *et al.* (2020) ^[22], Yadav *et al.* (2023) ^[17], and Verma *et al.* (2024) ^[24].

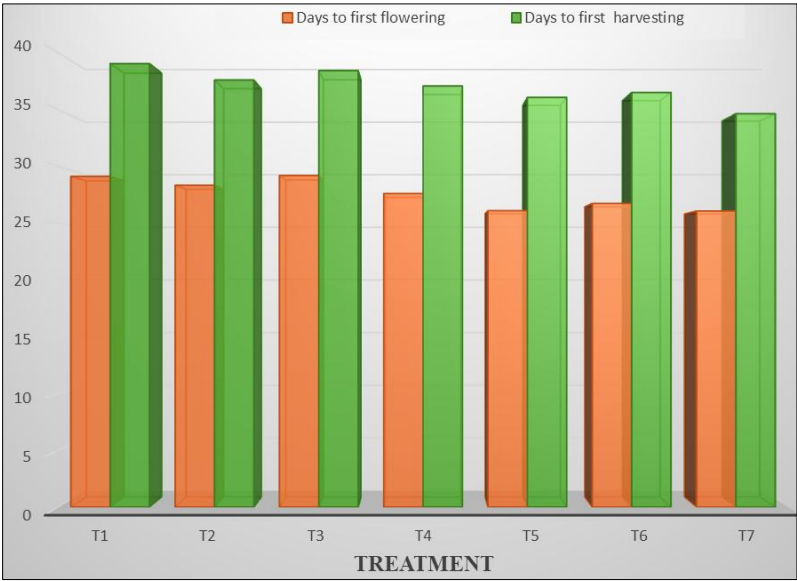


Table 3: Effect humic acid and micronutrients on days to first flowering & harvesting in cucumber

Treatment Notation	Treatments	Days to first lowering	Days to first harvesting
T ₁	RDF (control)	29.12	39.04
T ₂	RDF + humic acid 10 kg/ha (soil application)	28.34	37.60
T ₃	RDF + humic acid 0.1% (foliar spray)	29.02	38.43
T ₄	RDF + humic acid 10 kg/ha +humic acid 0.1% (foliar spray)	27.60	37.07
T ₅	RDF + humic acid 10kg/ha+ micronutrients mixture (foliar spray)	26.10	36.07
T ₆	RDF + humic acid 0.1%+micronutrients mixture (foliar spray)	26.73	36.05
T ₇	RDF + humic acid 10 kg/ha + humic acid 0.1% +micronutrients mixture (foliar spray)	26.07	34.63
SE(m) ±		0.49	0.50
C.D. (P=0.05)		1.53	1.58

Leaf area (cm²)

The impact of humic acid and micronutrients on leaf area (cm²) is depicted in Table 4 and Figure. The maximum leaf area (496.92 cm²) was recorded in T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients), while the minimum leaf area (433.57 cm²) was observed in the

Control (T₁). The increased leaf area under T₇ may be attributed to improved nutrient uptake, enhanced chlorophyll synthesis, and greater photosynthetic activity resulting from the combined application of humic acid and micronutrients. These findings are in agreement with Lakhan *et al.* (2020) ^[22], Yadav *et al.* (2023) ^[17], and Verma *et al.* (2024) ^[24].

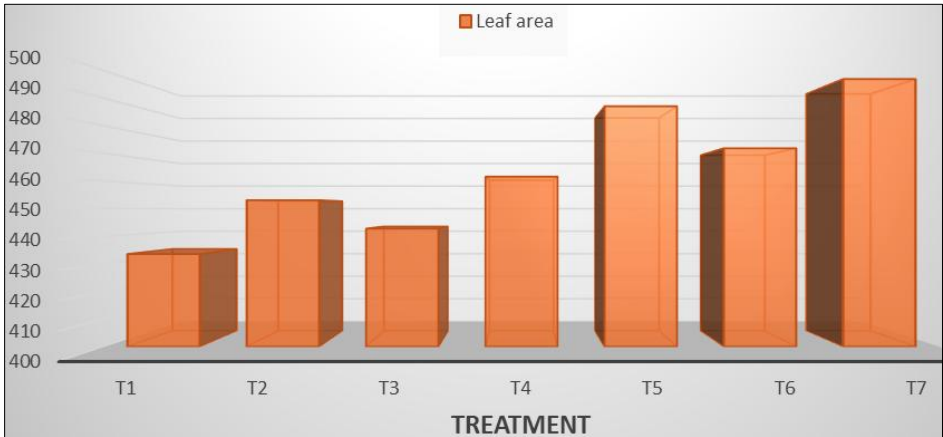


Table 4: Effect humic acid and micronutrients on leaf area (cm²) in cucumber

Treatment Notation	Treatments	leaf area (cm ²)
T ₁	RDF (control)	433.57
T ₂	RDF + humic acid 10 kg/ha (soil application)	453.09
T ₃	RDF + humic acid 0.1% (foliar spray)	442.77
T ₄	RDF + humic acid 10 kg/ha +humic acid 0.1% (foliar spray)	461.59
T ₅	RDF + humic acid 10kg/ha+ micronutrients mixture (foliar spray)	487.08
T ₆	RDF + humic acid 0.1%+micronutrients mixture (foliar spray)	471.87
T ₇	RDF + humic acid 10 kg/ha + humic acid 0.1% +micronutrients mixture (foliar spray)	496.92
SE(m) ±		7.32
C.D. (P=0.05)		22.83

Conclusion

The study concludes that the combined application of humic acid and micronutrients significantly improved the growth, yield, and quality parameters of cucumber under polyhouse conditions. Treatment T₇ (RDF + humic acid @ 10 kg ha⁻¹ soil application + humic acid 0.1% foliar spray + micronutrients) consistently recorded superior performance in all vegetative characteristics compared to other treatments and control. Overall, integrated nutrient management involving humic acid and micronutrients proved most effective for enhancing productivity and fruit quality of cucumber.

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