

## Studies on Influence of CPPU, Humic Acid and Paclobutrazol on Growth and Fruit Quality of Dragon Fruit *Hylocereus costaricensis* (Web.) Britton and Rose

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### ABSTRACT

The current study was conducted during the period of 2024-2025 at the dragon fruit plantation of the Department of Horticulture, School of Agricultural Science and Technology (SAST), Babasaheb Bhimrao Ambedkar University (BBAU), Lucknow, UP, India (26°55' N latitude and 80°54' E longitude, standing 123 meters MSL) in the subtropical climate having average temperatures dip to 2°C during winter, while summer highs often soar to 45°C along with 700 mm of annual rainfall where soil is sandy loam and slightly alkaline in nature with pH 8.1. The experiment was conducted in randomized block design (RBD) with 8 treatments and 3 replications to study the influence of CPPU, Humic acid and Paclobutrazol on growth

and fruit quality of dragon fruit. CPPU was applied as foliar spray and Humic acid & Paclobutrazol was applied as soil drenching. The results showed that CPPU @ 200 ppm + Humic acid @10% had significant positive impact on vegetative growth parameters (plant length, segment length, arch height) followed by improved thickness and circumference by the combined application of CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup>. Similarly, combined application of CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup> improved physical and chemical quality parameters of dragon fruits. Thus, combined application of CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup> two times during April and May on dragon fruit crop grown under subtropical climate of Lucknow may be suggested for better growth and improved fruit quality.

**Keyword** Dragon fruit, CPPU, Humic acid, Paclobutrazol, Vegetative growth, Fruit quality.

### INTRODUCTION

The dragon fruit, scientifically known as *Hylocereus* sp. (Syn. *Selenicereus* sp.) belongs to the Cactaceae family having chromosome no. 2n=22 is a perennial plant that thrives well in long-day conditions. It is commonly referred to by various names including Pitaya, Strawberry pear, Night blooming cereus, Queen

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of night, Honorable queen, *Cereus triangularis*, Jesus in the cradle and Belle of the night (Maji 2019). The term “hylos” derived from Greek word, which means “forest”, and the name *Hylocereus* reflects the plant’s ecological adaptations and its resilience to arid environments, attributed to the waxy coating known as cereus that protects its stems. This fruit is native to the tropical and subtropical regions of Mexico, Central America, and northern South America (Kakade *et al.* 2020). There are four primary types cultivated across different regions: *Hylocereus undatus* (Haworth) Britton and Rose (Red-skinned with white flesh), *Hylocereus polyrhizus* (F. A. C. Weber) Britton and Rose (Red-skinned with red flesh), *Hylocereus costaricensis* (Web.) Britton and Rose (Red-skinned with purple-red flesh), and *Hylocereus megalanthus* having yellow skin with white flesh (Mizrahi *et al.* 1997). Commercial cultivation of dragon fruit spans over 20 tropical and subtropical countries, including Vietnam, Bermuda, Myanmar, Malaysia, Indonesia, Philippines, Colombia, Israel, northern Australia, Japan, southern China, Sri Lanka, southern Florida, Taiwan, Bangladesh and Thailand (Mercado-Silva, 2018). Vietnam stands out as the leading producer with (51.1%), having introduced the fruit more than a century ago (Harithpriya and Jeychandran 2019). Together, Vietnam, China, and Indonesia contribute to over 93% of the global dragon fruit supply. China ranks as the second largest producer, responsible for 33.3% of global output, yielding over 700,000 MT from 40,000 hectares, with an average productivity of 17.5 MT/ha. Dragon fruit was introduced to India in the late 1990s (Karunakaran *et al.* 2024) and currently it is cultivated across several states in India including Maharashtra, Gujarat, Karnataka, Rajasthan, Punjab, Haryana, Madhya Pradesh, West Bengal, Uttar Pradesh and some north eastern states. Optimal growth conditions include elevations of approximately 1700 meters above sea level and temperatures ranging from 20-30°C (Karunakaran *et al.* 2014), it can be cultivated in various types of soil, but well-drained sandy loam rich in organic matter with a pH of 5.5 to 6.5 is ideal. As a shallow-rooted plant, it has a higher irrigation frequency compared to other cacti. The flowering starts from the second year of planting while commercial yield started from the age of 4-5 years and once the dragon fruit is planted it will grow for at least 20 years and approximately

5000-6000 plants per hectare depends upon the plant distance (Kakade *et al.* 2020).

In terms of nutritional content, 100 g edible dragon fruit contains approximately 80-90g of water, 4-25 mg of ascorbic acid, 0.4-0.7g of ash, 6-10mg of calcium, 35-50 calories, 9-14g of carbohydrates, traces of carotene (Vitamin A), 0.1-0.6g of fat, 0.3-0.9g of fibre, 0.3-0.7mg of iron, 0.2-0.45mg of niacin, 16-36 mg of phosphorus, 0.15-0.5g of protein, and traces of thiamine (Vitamin B1) and riboflavin (Vitamin B2) per 100g of fruit (Arivalagan *et al.* 2021). The red /purple pulp types of dragon fruit are particularly high in lycopene, a natural antioxidant. Dragon fruit is also beneficial for promoting wound healing and is often included in functional foods and nutraceutical products aimed at overweight individuals and diabetic patients (Rao and Sasanka 2015).

Various value-added products can be derived from dragon fruit, including jam, jelly, syrup, juice and wine made from its pulp. Additionally, the dried pulp and rind are utilized in the production of numerous cosmetic items. The natural dye extracted from the fruit serves as a colorant in the food industry (Parma and Karetha 2021).

Plant growth regulators are organic substances produced naturally in higher plants, controlling growth or other physiological functions at a site remote from its place of production and active in minute amounts (Sinha *et al.* 2018). Paclobutrazol belongs to triazole family and it is an extremely active chemical compounds that affects almost all plant species, whether used as foliar spray or as a soil drench. Paclobutrazol may be more effective when used as soil drench than the foliar spray due to enhance activity and low probability of stunting and flowering delay, because no direct contact to the flowers or flower buds (Million *et al.* 1999). It has been observed by several researchers its effect on reducing plant height and increased fruit number, weight and yield of fruits per tree in many crops (Patel *et al.* 2024).

CPPU (1-(2-chloro-4-pyridyl)-3-phenylurea) or Forchlorfenuron, is a potent plant growth regulator that enhances fruit development and quality across various species. Its primary functions include promot-

ing cell division, enlarging fruit size, and delaying senescence, making it valuable in agricultural practices. CPPU significantly improves quality attributes, such as sugar-acid ratios and vitamin C levels in kiwifruits (Chang 2021, Xie *et al.* 2024).

Humic acid is a complex organic substance derived from the decomposition of plant and animal matter having multifunctional properties make it a valuable resource for enhancing plant growth and promoting root development, nutrient absorption, and overall plant growth (Gutam *et al.* 2025). It enhances soil structure, increases microbial activity and improves nutrient retention, contributing to sustainable agricultural practices (Sun and Xia 2024).

In spite of these breakthroughs in comprehending the individual influences of CPPU, humic acid, and paclobutrazol on the development of fruits in various horticultural species, their collective impacts on dragon fruit remain largely unexamined. This gap in knowledge highlights the necessity for focused research to clarify the synergistic or opposing interactions between CPPU, Humic acid, and Paclobutrazol, as well as their consequences for dragon fruit cultivation.

Hence, keeping the above discussion in mind the present investigation was conducted to study the impact of CPPU, Humic acid and Paclobutrazol on vegetative growth and fruit quality of dragon fruit.

## MATERIALS AND METHODS

The current study was conducted during the period of 2024-2025 at the dragon fruit orchard (Dragon Fruit Innovation and Demonstration Centre) of the Department of Horticulture, School of Agricultural Science and Technology (SAS&T), Babasaheb Bhimrao Ambedkar University (BBAU), Lucknow, UP, India (26°55' N latitude and 80°54' E longitude, standing 123 meters MSL) comes under the subtropical climate. In winter, average temperatures can dip to 2°C, while summer highs often soar to 45°C. Annually, the area receives about 700 mm of rainfall, with the majority occurring from June to September. The soil status of the dragon fruit orchard is sandy loam and slightly alkaline in nature with soil pH

7.7 having uniform topography. The experiment is conducted in randomized block design (RBD) with 8 treatments (T<sub>0</sub>-Control, T<sub>1</sub>-CPPU@200 ppm foliar spray, T<sub>2</sub>-Humic Acid @10% soil drenching, T<sub>3</sub>-Paclobutrazol @1.5 g a.i./m<sup>2</sup> soil drenching, T<sub>4</sub>-CPPU@200 ppm + Humic Acid @10%, T<sub>5</sub>-CPPU@200 ppm+ Paclobutrazol @1.5 g a.i./m<sup>2</sup>, T<sub>6</sub>-Humic Acid @10%+Paclobutrazol @1.5 g a.i./m<sup>2</sup>, T<sub>7</sub>-CPPU@200 ppm+ Humic Acid @10%+Paclobutrazol @1.5 g a.i./m<sup>2</sup>) which were replicated thrice. CPPU was applied as foliar spray and Humic acid & Paclobutrazol was applied as soil drenching two times during April and May. The vegetative growth parameters like plant length, segment length, number of areoles, number of spines etc were investigated and biochemical fruit quality parameters like fruit weight, fruit shape index, peel characters, pulp characters, TSS, sugar content, vitamin c content were analyzed as per standard methods (Ranganna 1986). The observed data were statistically analyzed using OPSTAT (Sheoran *et al.* 1998) and treatment means were compared at 5% level of significance (Sahu and Das 2014).

## RESULTS AND DISCUSSION

### *Plant length (cm)*

The result of the experiment (Table 1) revealed that the plant height was significantly influenced by the application treatments. It was observed that from 60 to 90 DAT lowest increase in plant length was observed in treatment T<sub>4</sub> (0.43 cm). However, maximum overall growth from 0 to 150 DAT was 2.92 cm in treatment T<sub>4</sub> followed by 2.62 cm in T<sub>7</sub>. Overall minimum increase in plant length was 1.37 cm, noted in T<sub>3</sub>.

### *Segment length (cm)*

The result revealed that 60 to 90 days maximum change was seen in treatment T<sub>4</sub> (0.28 cm) which also showed the maximum overall increase in segment length (1.74 cm) followed by 1.49 cm in T<sub>7</sub>. Overall least increase in segment length was 0.61 cm, noted in T<sub>3</sub>.

### *Number of areoles per segment*

The application of CPPU @200 ppm, Humic Acid

**Table 1.** Effect of CPPU, Homic acid and Paclobutrazol on increase in plant length, Segment length and number of areoles per segment of dragon fruit.

Treatment	Plant length (cm) of dragon fruit				Segment length (cm)				Number of areoles per segment			
	increase in plant length (0-30 DAT)	increase in plant length (30-60 DAT)	increase in plant length (60-90 DAT)	Total increase in plant length (0-150 DAT)	Increase in Segment length at (0- 30 DAT)	Increase in Segment length at (30- 60 DAT)	Increase in Segment length at (60- 90 DAT)	Total increase in Segment length (0-150 DAT)	Increase in number of areoles/ segment at (0- 30 DAT)	Increase in number of areoles/ segment at (30- 60 DAT)	Increase in number of areoles/ segment at (60- 90 DAT)	Total increase in number of areoles per segment (0-150 DAT)
T <sub>0</sub>	0.22	0.20	0.23	1.72	0.10	0.09	0.13	0.80	0.00	0.00	0.11	0.55
T <sub>1</sub>	0.38	0.35	0.35	2.40	0.18	0.17	0.17	1.34	0.00	0.00	0.22	0.89
T <sub>2</sub>	0.35	0.32	0.30	2.22	0.15	0.14	0.16	1.22	0.00	0.00	0.11	0.56
T <sub>3</sub>	0.18	0.17	0.20	1.37	0.09	0.08	0.10	0.61	0.11	0.00	0.11	0.33
T <sub>4</sub>	0.47	0.43	0.43	2.92	0.21	0.19	0.28	1.74	0.00	0.00	0.11	1.00
T <sub>5</sub>	0.30	0.27	0.33	2.08	0.12	0.11	0.17	1.10	0.00	0.00	0.11	0.56
T <sub>6</sub>	0.28	0.25	190	1.93	0.11	0.09	0.17	1.02	0.00	0.00	0.00	0.56
T <sub>7</sub>	0.42	0.38	199.95	2.62	0.19	0.17	0.23	1.49	0.00	0.00	0.11	0.89
SEm (±)	0.017	0.026	0.033	0.209	0.015	0.026	0.026	0.057	0.039	...	0.106	0.143
CD (p=0.05)	0.053	0.078	0.100	0.068	0.047	0.078	0.078	0.174	NS	...	NS	NS

(T<sub>0</sub> – Control, T<sub>1</sub> - CPPU@200ppm, T<sub>2</sub> - Humic Acid @ 10%, T<sub>3</sub>-Paclobutrazol @1.5 g.a.i./m<sup>2</sup>, T<sub>4</sub>- CPPU@200 ppm + Humic Acid@10%, T<sub>5</sub>-CPPU@200 ppm+ Paclobutrazol @1.5 g.a.i./m<sup>2</sup>, T<sub>6</sub> - Humic Acid @ 10% +Paclobutrazol@1.5 g.a.i./m<sup>2</sup>, T<sub>7</sub>- CPPU@200 ppm + Humic Acid @10% + Paclobutrazol@1.5 g.a.i./m.

**Table 2.** Effect of CPPU, Humic acid and Paclobutrazol on increase of arch height, segment thickness and stem circumference of dragon fruit.

Treatment	Arch height (mm)				Segment thickness (cm)				Stem circumference (cm)			
	Increase arch height at (0-30 DAT)	Increase arch height at (30-60 DAT)	Increase arch height at (60-90 DAT)	Total increase in Arch height (0-150 DAT)	Increase segment thickness at (0-30 DAT)	Increase segment thickness at (30-60 DAT)	Increase segment thickness at (60-90 DAT)	Total increase in segment thickness (0-150 DAT)	Increase stem circumference at (0-30 DAT)	Increase stem circumference at (30-60 DAT)	Increase stem circumference at (60-90 DAT)	Total increase in Stem circumference (0-150 DAT)
T <sub>0</sub>	0.00	0.00	0.07	0.75	0.00	0.00	0.07	0.75	0.15	0.12	0.11	0.83
T <sub>1</sub>	0.33	0.23	0.28	1.83	0.33	0.23	0.28	1.83	0.21	0.17	0.16	1.08
T <sub>2</sub>	0.17	0.17	0.10	1.33	0.17	0.17	0.10	1.33	0.20	0.18	0.16	1.08
T <sub>3</sub>	0.00	0.00	0.00	0.58	0.00	0.00	0.00	0.58	0.22	0.19	0.17	1.10
T <sub>4</sub>	0.50	0.33	0.40	2.47	0.50	0.33	0.40	2.47	0.21	0.19	0.18	1.15
T <sub>5</sub>	0.33	0.17	0.17	1.58	0.33	0.17	0.17	1.58	0.19	0.20	0.19	1.12
T <sub>6</sub>	0.33	0.17	0.23	1.72	0.33	0.17	0.23	1.72	0.18	0.20	0.20	1.08
T <sub>7</sub>	0.37	0.30	0.33	2.03	0.37	0.30	0.33	2.03	0.23	0.23	0.20	1.30
SEm (±)	0.183	0.165	0.108	0.276	0.183	0.165	0.108	0.276	0.025	0.022	0.02	0.052
CD (p=0.05)	NS	NS	NS	0.844	NS	NS	NS	0.844	---	---	---	0.16

**Table 3.** Effect of CPPU, Humic acid and Paclobutrazol on morphological fruit quality of dragon fruit.

Treatment	Fruit weight (g)	Fruit volume (cc)	Specific gravity (g/cc)	Longitudinal diameter (mm) of fruit	Transverse diameter (mm) of fruit	Fruit shape index	Number of scales per fruit
T <sub>0</sub>	165	160	1.03	80.5	62.56	1.31	27
T <sub>1</sub>	259	275	0.94	91.24	71.60	1.27	34
T <sub>2</sub>	241	250	0.96	94.06	74.49	1.26	33
T <sub>3</sub>	189	160	1.18	88.21	63.78	1.38	20
T <sub>4</sub>	293	300	0.98	101.7	76.54	1.33	30
T <sub>5</sub>	192	205	0.94	88.29	64.50	1.37	31
T <sub>6</sub>	239	245	0.98	93.41	73.44	1.27	30
T <sub>7</sub>	302	300	1.01	90.68	78.72	1.25	33
SEm (±)	0,139	1,044	0.003	0.142	0.18	0.009	0.408
CD (p=0.05)	0.425	3.196	0.009	0.434	0.552	0.028	1.25

@10% and Paclobutrazol @1.5 g a.i./m<sup>2</sup> showed no significant increase in number of areoles (0-90 DAT). However, maximum overall increase from 0 to 150 DAT was seen in treatment T<sub>4</sub> (1.00), followed by T<sub>7</sub> and T<sub>1</sub> (0.89) and minimum increase in number of areoles was 0.33, noted in T<sub>3</sub>.

#### **Arch height (mm)**

A non-significant influence (Table 2) due to application of CPPU @200 ppm, Humic Acid@10% and Paclobutrazol @1.5 g a.i. per meter of canopy diameter on arch height was seen from 0 to 30 DAT, 30 to 60 DAT, 60 to 90 DAT and overall effect from 0 to 150 DAT. But maximum change was 0.50 mm in T<sub>4</sub> followed by 0.50 mm in T<sub>7</sub> (0 – 60 DAT), 0.40 mm during 60 to 90 DAT and overall best increase in arch height during 0-150 was 2.47 mm found in treatment T<sub>4</sub>, followed by 2.03 mm in T<sub>7</sub>.

#### **Segment thickness (cm)**

From 0 to 30 DAT maximum change in segment thickness was noticed in treatment T<sub>7</sub> (0.08 cm) followed by 0.07 cm in treatment T<sub>3</sub>, 0.06 cm in T<sub>4</sub> but these were statistically at par. From 30 to 60 DAT maximum change was 0.08 cm observed in treatment T<sub>7</sub> followed by 0.07 cm in T<sub>3</sub> and T<sub>4</sub>. During 60 to 90 DAT maximum change was noted 0.09 cm in T<sub>7</sub>. However, maximum overall increase in segment thickness was 0.52 cm found in treatment T<sub>7</sub> (CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup>) and least increase in segment thickness was 0.26 cm, noted in T<sub>0</sub> (Control).

#### **Stem circumference (cm)**

From 0 to 60 DAT there was non-significant change in circumference but from 60 to 90 DAT and 0 to 150 DAT there was significant changes in circumference. From 0 to 30, 30 to 60 and 60 to 90 DAT maximum change was recorded 0.23 cm, 0.23 cm and 0.23 cm, respectively in treatment T<sub>7</sub> followed by T<sub>4</sub>.

#### **Effect of CPPU, humic acid and paclobutrazol on fruit quality of dragon fruit**

##### **Fruit weight (g)**

The maximum fruit weight (302 g) was recorded from the plants which were treated with CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup> (T<sub>7</sub>). It was followed by the T<sub>4</sub> (293 g) with CPPU@200 ppm + Humic Acid @10%. The statistical analysis showed a clear difference between the treatments, suggesting that they were effective in producing distinct outcomes. The minimum fruit weight 165 g was recorded from control plants (T<sub>0</sub>) (Table 3).

##### **Volume of fruit (cc)**

The data concerning fruit volume of dragon fruit influenced by application of CPPU, Humic Acid and Paclobutrazol was presented in Table 3. The maximum fruit volume (300 cc) was noted from the plants which were treated with CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup> (T<sub>7</sub>) and the minimum fruit volume 160 cc was recorded on T<sub>0</sub> (Control).

**Table 4.** Effect of CPPU, Humic acid and Paclobutrazol on pulp and peel characters of dragon fruit.

Treatment	Peel thickness (mm)	Pulp thickness (mm)	Peel weight (g)	Pulp weight (g)	Pulp: peel ratio (w/w)	Edible index (%)	Waste index (%)
T <sub>0</sub>	2.50	56.00	51.40	137.60	2.68	72.80	27.20
T <sub>1</sub>	3.00	69.00	68.00	191.00	2.81	73.75	26.25
T <sub>2</sub>	3.00	64.00	78.00	163.00	2.09	67.63	32.37
T <sub>3</sub>	2.50	56.00	51.40	113.60	2.21	68.85	31.15
T <sub>4</sub>	3.20	68.00	72.00	221.00	3.07	75.43	24.57
T <sub>5</sub>	2.50	62.00	54.80	137.20	2.50	71.46	28.54
T <sub>6</sub>	3.00	65.00	71.00	168.00	2.37	70.29	29.71
T <sub>7</sub>	3.50	70.00	58.00	244.00	4.52	80.79	19.21
SEm (±)	0.009	0.926	0.038	1.086	0.023	0.009	0.008
CD (p=0.05)	0.028	2.835	0.116	3.326	0.069	0.029	0.023

**Specific gravity (g/cc)**

The highest specific gravity was recorded from the plant treated with Paclobutrazol @1.5 g a.i./m<sup>2</sup> T<sub>3</sub> (1.18), followed by 1.03 in T<sub>0</sub> (Control) and lowest specific gravity was noticed 0.94 in treatment T<sub>5</sub>.

**Longitudinal diameter (mm)**

The maximum longitudinal diameter (101.7 mm) was recorded from the plants which were treated with CPPU@200 ppm + Humic Acid @10% (T<sub>4</sub>) and followed by the T<sub>2</sub> (94.06 mm) and the minimum longitudinal diameter was observed 80.5 mm from control plant (T<sub>0</sub>).

**Transverse diameter (mm)**

The result of the experiment revealed that transverse diameter was significantly influenced by the application of CPPU, Humic Acid and Paclobutrazol. The maximum transverse diameter (78.72 mm) was recorded with T<sub>7</sub>. It was followed by T<sub>4</sub> (76.54 mm). The statistical analysis showed a clear difference between the treatments, suggesting that they were effective in producing distinct outcomes. Minimum transverse diameter was 61.56 mm observed from control plant (T<sub>0</sub>).

**Fruit shape index**

The result of the investigation revealed that highest fruit shape index (Longitudinal diameter (mm)/

Transverse diameter (mm)) was 1.38 (in treatment T<sub>3</sub> (Paclobutrazol @1.5g a.i./m<sup>2</sup>) followed by 1.37 in T<sub>5</sub> (CPPU@200 ppm+ Paclobutrazol @1.5 g a.i./m<sup>2</sup>) and lowest 1.15, observed with T<sub>7</sub>(CPPU@200 ppm + Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>).

**Number of scales per fruit**

The analysis revealed the significant influence of CPPU, Humic Acid and Paclobutrazol on number of scales per fruit of dragon fruit. The highest number of scales was recorded from the plant treated with CPPU@200 ppm T<sub>1</sub> (34), followed by 33 in both T<sub>2</sub> and lowest number of scales was observed in treatment T<sub>3</sub> (20).

**Peel thickness (mm)**

The analysis (Table 4) revealed the significant influence of CPPU, Humic Acid and Paclobutrazol on peel thickness of dragon fruit. Maximum peel thickness was observed 3.50 mm in T<sub>7</sub> (CPPU@200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>), followed by 3.20 mm in T<sub>4</sub> (CPPU@200 ppm+ Humic Acid @10%). Minimum peel thickness was 2.50 mm observed in T<sub>3</sub>, T<sub>5</sub> and control.

**Peel weight (g)**

Maximum fruit peel weight was recorded on T<sub>2</sub> (78g), followed by T<sub>4</sub> (72 g) and minimum fruit peel weight was observed 51.40 g in T<sub>0</sub> (control) and T<sub>3</sub> (Paclobutrazol @1.5 g a.i./m<sup>2</sup>).

**Table 5.** Effect of CPPU, Humic acid and Paclobutrazol on chemical quality parameters of dragon fruit.

Treatment	TSS (°B)	Titratable acidity (%)	TSS: Acid ratio	Ascorbic acid (mg/100g)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugars (%)
T <sub>0</sub>	15.2	0.138	110.14	20.23	5.88	1.32	7.21
T <sub>1</sub>	19.2	0.133	144.36	22.10	8.70	1.75	10.45
T <sub>2</sub>	15.3	0.135	113.33	16.42	8.02	1.48	9.5
T <sub>3</sub>	16	0.142	112.68	18.33	7.24	1.35	8.56
T <sub>4</sub>	16.9	0.128	132.03	21.66	8.28	1.67	9.91
T <sub>5</sub>	16.1	0.138	116.67	21.66	8.85	1.60	10.46
T <sub>6</sub>	16.4	0.136	120.59	20.23	9.21	1.77	10.98
T <sub>7</sub>	19.6	0.130	150.77	22.14	9.47	1.91	11.38
SEm (±)	0.006	0.001	0.705	0.455	0.215	0.01	0.408
CD (p=0.05)	0.019	0.002	2.139	1.395	0.659	0.031	1.25

**Pulp thickness (mm)**

The highest pulp thickness was recorded from treatment T<sub>7</sub> (70 mm), followed by 69 mm in T<sub>1</sub>, 68 mm in T<sub>4</sub> while the lowest pulp thickness was (56 mm) recorded from control plant (T<sub>0</sub>).

**Pulp weight (g)**

Maximum fruit pulp weight recorded from treatment T<sub>7</sub> (244 g) by the application of CPPU@200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>, followed by 221 g in T<sub>4</sub> and lowest fruit pulp was recorded from T<sub>3</sub> (113.60 g) by the application of Paclobutrazol @1.5 g a.i./m<sup>2</sup>.

**Edible index (%)**

Highest edible percentage (80.79%) was recorded from treatment T<sub>7</sub>, followed by 75.43 % in T<sub>4</sub>, 73.75 % in T<sub>1</sub> and lowest edible index percentage was 67.63% noted from treatment T<sub>2</sub> (Humic Acid @10% soil drenching).

**Waste index (%)**

The data revealed the significant influence on waste index percentage of dragon fruit. Maximum waste index percentage was 32.37% in treatment T<sub>2</sub> (Humic Acid @10%), followed by 31.15% in treatment T<sub>3</sub> (Paclobutrazol @1.5 g a.i./m<sup>2</sup>) and the minimum waste index percentage was (19.21%) recorded from treatment T<sub>7</sub> (CPPU@200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>).

**Pulp: peel ratio (w/w)**

The analysis revealed the significant influence of CPPU, Humic Acid and Paclobutrazol on pulp to peel ratio of dragon fruit. Maximum pulp to peel ratio was 4.52 observed in treatment T<sub>7</sub>, followed by 3.07 in T<sub>4</sub>, 2.81 in treatment T<sub>1</sub> and 2.68 in control (T<sub>0</sub>). Minimum pulp to peel ratio was 2.09 in treatment T<sub>2</sub>.

**TSS (°Brix)**

The result of the experiment as presented in Table 5 revealed that TSS of fruit was significantly influenced by the application of CPPU, Humic Acid and Paclobutrazol. The maximum TSS (19.6) was recorded from the plants which were treated with CPPU@200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup> (T<sub>7</sub>). It was followed by T<sub>1</sub>(19.2), T<sub>4</sub> (16.9) and the minimum TSS 15.2 was recorded from control plant (T<sub>0</sub>).

**Titratable acidity (in term of citric acid)**

The maximum titratable acidity (citric acid) (0.142) was recorded from the plant that was treated with Paclobutrazol @1.5 g a.i./m<sup>2</sup> (T<sub>3</sub>). Minimum titratable acidity was recorded 0.128 from treatment T<sub>4</sub>(CP-PU@200 ppm + Humic Acid @10%).

**TSS: Acid ratio**

Highest TSS: Acid ratio was recorded from treatment T<sub>7</sub> (150.77) by the application of CPPU@200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>. It

was followed by the 144.36 in treatment T<sub>1</sub>, 132.04 in T<sub>4</sub> and minimum TSS: Acid ratio was recorded from T<sub>0</sub> (110.14) control plant.

#### ***Ascorbic acid (mg/100g FW of edible part)***

There was a significant influence of CPPU, Humic Acid and Paclobutrazol on ascorbic acid content of dragon fruit. Highest ascorbic acid content was (22.143 mg) found in treatment T<sub>7</sub>(CPPU@200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>). It was followed by T<sub>1</sub> (22.1 mg). Lowest ascorbic acid content was 16.42 mg, recorded from treatment T<sub>2</sub> (Humic Acid @10%).

#### ***Reducing sugar (%)***

Table 5 also presented that the maximum reducing sugar was recorded from treatment T<sub>7</sub> (9.47%), followed by T<sub>6</sub> (9.21%) and T<sub>5</sub> (8.85 %) i.e. by the application of CPPU @200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>, Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup> and CPPU @200 ppm+ Paclobutrazol @1.5 g a.i. Minimum reducing sugar was (5.88%) observed in control (T<sub>0</sub>).

#### ***Non-reducing sugar (%)***

The result of the experiment revealed that the non-reducing sugar content of dragon fruit was significantly influenced by the application of CPPU, Humic Acid and Paclobutrazol. Highest non-reducing sugar was observed in treatment T<sub>7</sub> (1.91%), followed by T<sub>6</sub> (1.77). Minimum non-reducing sugar was recorded from T<sub>0</sub> (1.32%) control plant.

#### ***Total sugars (%)***

Highest total sugar was recorded 11.38% from treatment T<sub>7</sub> followed by 10.98 % in T<sub>6</sub>, 10.46% in T<sub>5</sub> and 10.45 % in treatment T<sub>1</sub> i.e. by the application of CPPU@200 ppm+ Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>, Humic Acid @10% +Paclobutrazol @1.5 g a.i./m<sup>2</sup>, CPPU@200 ppm+ Paclobutrazol @1.5 g a.i./m<sup>2</sup>, CPPU@200 ppm, respectively. Lowest total sugar was reported in treatment T<sub>0</sub> (control) 7.21%.

## **DISCUSSION**

### ***Effect of CPPU, humic acid and paclobutrazol on vegetative growth parameters of dragon fruits***

The result of the present research indicating an increase in plant length, segment length, number of areoles per segment in Table 1 and arch height, segment thickness, stem circumference is presented in Table 2, the maximum increase in plant length, segment length and number of areoles per segment was recorded under treatment T<sub>4</sub> followed by T<sub>7</sub>, during the period of 120 to 150 DAT. The enhancement of above vegetative growth parameters attributed to CPPU and Humic acid may be due to the Cytokinin-like activity of CPPU combined with the hormonal modulation by humic acid may amplify cell division and expansion processes, ultimately leading to increased vegetative growth. Similar pattern was also observed by Hota *et al.* (2017) in apricot and by Singh *et al.* (2025) in strawberry. The maximum increase in segment thickness and stem circumference was recorded under treatment T<sub>7</sub>. This may be due to the combined effect of CPPU, Humic acid and Paclobutrazol, where CPPU indicating its role in promoting cell division and expansion, Humic acid improves soil fertility and stimulate plant growth by enhancing nutrient uptake and root development and paclobutrazol inhibits gibberellin biosynthesis, leading to reduced vegetative growth and shorter internodes. Most significant growth observed during 90 to 150 DAT which may be due to favorable growth conditions of dragon fruit.

### ***Effect of CPPU, humic acid and paclobutrazol on fruit quality of dragon fruits***

The findings from the present study had a significant effect on fruit weight and fruit volume. Highest fruit weight and fruit volume was observed in treatment T<sub>7</sub> while lowest fruit weight and volume was reported in control. Increase fruit weight and volume could be the result of synergistic effects of CPPU, Humic acid and Paclobutrazol. CPPU drives cell expansion, humic acid improves metabolic support, and paclobutrazol ensures more assimilates are directed to fruit rather than vegetative growth. The results were in agreement with Flaishman *et al.* (2001) in pear and Wassel *et al.* (2007) in grapevine.

Longitudinal diameter and transverse diameter are important for fruit characterization and ratio of Longitudinal and transverse diameter indicates fruit shape. Maximum longitudinal diameter was recorded from T<sub>4</sub> which could be due to the cell division and enlargement by CPPU and improved nutrient absorption, root growth, and photosynthesis due to humic acid. Maximum transverse diameter was recorded from T<sub>7</sub> which may be due to combined interaction of CPPU, Humic acid and of paclobutrazol which enhances transverse diameter reduced shoot elongation by inhibiting gibberellins, thus diverting energy to fruit developing more compact, filled-out fruit.

Highest number of scales was recorded in treatment T<sub>1</sub> which may be due to the cytokinin activity in peel tissue which promotes cell division and elongation by effect of CPPU. Maximum pulp thickness and pulp weight was recorded from treatment T<sub>7</sub>. It could be due to the synergistic effect of CPPU, humic acid, and paclobutrazol which enhances pulp expansion and fortification in dragon fruit by synchronizing hormonal balance, nutrient flow, and carbohydrate partitioning. Paclobutrazol slows down plant growth by blocking gibberellins, the hormones that cause tall, leafy growth. This helps the plant focus its energy on making better fruits instead of more leaves. CPPU encourages the fruit's inner flesh (pulp) to grow by speeding up cell division, making the fruit juicier and heavier. Humic acid works underground boosting root health and helping the plant absorb more nutrients, which in turn improves both fruit quality and peel strength.

The total soluble solids were recorded maximum in T<sub>7</sub>. It may be due to the combined use of CPPU, humic acid, and paclobutrazol which significantly enhances TSS in *Hylocereus* (dragon fruit) through coordinated effects on sugar accumulation, source-sink regulation, and nutrient uptake. This result is also in accordance with finding of Wassel *et al.* (2007) who recorded higher total soluble solids (TSS), TSS/Acidity ratio than control in grapevine by application of paclobutrazol.

Lowest titratable acidity, highest ascorbic acid, total sugars including reducing sugars and non-reducing sugars was found maximum in treatment T<sub>7</sub>. The

combined treatment effectively reduces titratable acidity in dragon fruit while increasing sweetness (TSS), Ascorbic acid (Vitamin C) plays a key role in making dragon fruit healthier and tastier, enhancing the overall flavor profile. CPPU boosts sugar over acid accumulation, it boosts the fruit's antioxidant power, improves its overall quality, and helps it stay fresh longer. When CPPU, humic acid, and paclobutrazol are used together, they work in harmony to increase the Vitamin C content by influencing metabolic activities and nutrient availability during fruit development and ripening, Humic acid enhances acid metabolism via enzyme activation and paclobutrazol slows vegetative respiration, stabilizes acids early. For better palatability, TSS: acidity ratio of fruits is important. Maximum TSS: acidity ratio was recorded in treatment T<sub>7</sub> due to higher TSS and lower acidity. It could be due to the combined effect of CPPU, Humic acid and paclobutrazol by mechanism of sugar accumulation, by promoting sugar biosynthesis, transport, and conversion efficiency. CPPU enhances sugar flow into the fruit and humic acid supports sugar formation at the cellular level while Paclobutrazol ensures sugar is not lost to vegetative growth. Together, they make the fruit sweeter, better textured, and more commercially appealing. Similar findings were reported by Wassel *et al.* (2007).

## CONCLUSION

Current study revealed that CPPU, Humic acid and Paclobutrazol had a beneficial impact on vegetative growth and fruit quality of dragon fruit crops. CPPU @200 ppm + Humic acid @10% had significant positive effect on vegetative growth parameters (plant length, segment length, arch height) followed by improved thickness and circumference by the combined application of CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup>. Similarly, combined application of CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup> improved physical and chemical quality parameters of dragon fruits weight more fruit size, higher edible index. Thus, combined application of CPPU @200 ppm + Humic Acid @10% + Paclobutrazol @1.5 g a.i./m<sup>2</sup> two times during April and May on dragon fruit crop grown under subtropical climate of Lucknow may be suggested for better growth and fruit quality.

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