

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating: 5.29
 IJABR 2025; 9(7): 196-199
www.biochemjournal.com
 Received: 20-04-2025
 Accepted: 23-05-2025

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Effect of different training systems on growth and vigour in passion fruit (*Passiflora edulis*) under prayagraj agro-climatic region

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DOI: <https://www.doi.org/10.33545/26174693.2025.v9.i7c.4749>

Abstract

The trial was conducted at the Department of Horticulture, Naini Agriculture Institute, SHUATS Prayagraj, from May to October 2024. It was designed using a Randomized Block Design, comprising nine treatments: T0 Control, T1 Kniffin System (2 arms), T2 Kniffin System (4 arms), T3 High Trellis System (Single Cordon), T4 High Trellis System (Double Cordon), T5 Tatura System (4 arms), T6 Tatura System (4 arms), T7 Bower System (2 cordons), and T8 Bower System (4 cordons), each with three replications. The treatments in each replication were assigned randomly. Observations were recorded based on the vegetative growth parameters and chlorophyll content (SPAD VALUE). The lowest cost was found in the T4 High Trellis System (Double Cordon).

Keywords: Passion fruit, training systems, treatment, replication

Introduction

Passion fruit (*Passiflora edulis* Sims.), often viewed as a minor fruit in India, produces delicious fruit available in two varieties: Purple (*Passiflora edulis* f. *edulis*) and Yellow (*Passiflora edulis* f. *flavicarpa*) (Joy 2010) [9]. Native to Brazil, passion fruit belongs to the Passifloraceae family and primarily grows in tropical and subtropical regions, including South America, Australia, Asia, and Africa. In India, passion fruit is cultivated in Himachal Pradesh, Kerala, Tamil Nadu (Nilgiris Hills and Kodaikanal), Karnataka (Coorg), and the northeastern states (Mizoram, Nagaland, Manipur, and Sikkim), covering an area of 9.11 thousand hectares and yielding 25.82 thousand tons (Chonyaphai et. al 2022). Passion fruit is a perennial, vigorous, climbing woody vine producing round, oval-shaped fruit. The fruit contains orange-colored pulpy juice with numerous small, hard, dark brown to black pitted seeds. Popular for its rich flavor and blending quality, it contains sugars, acids, and vitamins, including Vitamin A (1300-2500 IU per 100 g pulp) and Vitamin C (30-50 mg per 100g pulp). Medicinally, passion fruit is used as a mild diuretic, digestive aid, and heart tonic, as well as to treat asthma. Passion fruit vines are trained to grow from a single shoot starting at the plant's base and extending upward to a trellis. At the top, two strong primary branches are guided to grow in opposite directions along the trellis. From these main branches, smaller lateral branches grow downward, serving as the primary sites for fruit production. Tendrils and excess growth are regularly pruned to maintain structure and optimize fruit yield. Training passion fruit vines involves various systems designed to guide vine growth, maximize space utilization, and enhance fruit production (Sulladmath et al. 2012) [14]. This study attempts to evaluate the effect of different training systems on the growth and vigour of passion fruit under Prayagraj agro climatic conditions.

Materials and Methods

The experiment was conducted during the 2024-2025 season in the Department of Horticulture at Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences in Prayagraj. Located in the southeastern part of Uttar Pradesh, Prayagraj falls within a subtropical climate zone characterized by extremely hot summers and relatively cool winters. Summer temperatures can reach as high as 46-48 °C, whereas

winter temperatures may drop to around 4-5 °C. Relative humidity in the region ranges from 20% to 94%, and it receives an average annual rainfall of approximately 1013.4 mm.

A Randomized Block Design (RBD) with three replications was employed to evaluate the performance of four distinct training systems: The Kniffin system (with 2-arm and 4-arm configurations), the High trellis system (featuring single and double cordons), the Tatura system (with 4-arm and 8-arm variations), and the Bower system (comprising 2 cordons and 4 cordons). Old seedlings were initially transplanted into the main field, followed by the transplantation of passion fruit seedlings at a spacing of 1.5 m × 1.5 m. Vegetative growth parameters—including plant height (cm), the number of leaves, chlorophyll content (as measured by SPAD values), and stem diameter (mm)—were recorded and statistically analyzed using the methodology described by Panse and Sukhatme (1967).

Results and Discussion

The study evaluated several vegetative growth parameters—plant height (cm), number of leaves per plant, chlorophyll content (SPAD value), and stem diameter (mm). The data, presented as mean values in the accompanying tables, were statistically analyzed to ensure accuracy and reliability.

Number of Leaves: The T₇ Bower system with 2 cordons recorded the highest number of leaves per plant, an average of 174. This was followed by the T₈ Bower system (4 cordons) and the T₆ Tatura system (8 arms). In contrast, the T₂ Kniffin system (4 arms) exhibited the lowest leaf count, an average of 40.6 leaves per plant.

Plant Height: Plant height reached its maximum of 169 cm in the T₈ Bower system (4 cordons). The T₇ Bower system (2 cordons) and the T₅ Tatura system (4 arms) also produced notably high plant heights. Conversely, the T₀ Control consistently recorded the lowest plant height at 115 cm.

Stem Diameter: Regarding stem diameter, the T₇ Bower system (2 cordons) yielded the largest girth at 6.38 mm. This was closely followed by the T₈ Bower system (4 cordons) and the T₂ Kniffin system (4 arms). The smallest stem diameter of 4.5 mm was observed in the T₁ Kniffin system (2 arms).

Chlorophyll Content: Chlorophyll content, measured by SPAD values, was highest in the T₈ Bower system (4 cordons) with an average value of 52.4. The T₇ Bower system (2 cordons) and the T₂ Kniffin system (4 arms) also recorded high chlorophyll levels, whereas the T₃ High Trellis system (single cordon) registered the lowest SPAD value at 45.3.

Collectively, these findings indicate that training systems significantly influence vegetative growth parameters. In particular, the Bower system—with both its 2-cordon and 4-cordon configurations—consistently resulted in enhanced growth, underscoring its potential for improving plant vigor and productivity.

Discussion

The differences in vegetative growth parameters among the various training systems are strongly linked to how each

system alters the plant's microenvironment and internal physiological processes.

- Enhanced Light Interception and Photosynthetic Efficiency:** In training systems such as the Bower configurations (T₇ and T₈), the spatial arrangement promotes an open and uniformly distributed canopy. This design minimizes self-shading, thereby ensuring that a larger fraction of the leaf area receives optimal light. Enhanced light interception directly improves photosynthetic activity, leading to increased synthesis of assimilates. These assimilates fuel further leaf development, plant elongation, and stem thickening. Several studies have shown that improved canopy architecture is crucial for maximizing light energy capture, which in turn enhances overall plant growth (Fuzy *et al.*, 2019).
- Optimized Resource Partitioning:** The increase in photosynthetic efficiency due to better light distribution results in a higher carbohydrate supply. This extra energy is allocated to various growth components, leading to longer plant height, thicker stems, and a greater number of leaves. This is partly regulated by a balanced interplay of phytohormones such as auxins and cytokinins, which control cell division and elongation. The improved resource partitioning observed in the Bower systems reflects an efficient source-sink relationship, a concept that has been extensively discussed in crop physiology literature (Kingara and Kaur, 2017).
- Microclimatic Modifications and Stress Mitigation** The architectural design of the training system also influences the local microclimate. Systems like the Bower configurations offer better air circulation and prevent the buildup of heat and humidity around the foliage. Reduced microclimatic stress helps maintain optimal enzymatic and metabolic activity, thus supporting active chlorophyll synthesis and photosynthesis (Kingara and Kaur, 2017). In contrast, more compact systems may create microenvironments that exacerbate thermal or water stress, leading to lower growth performance.
- Mechanical Stimuli and Thigmomorphogenesis:** The training systems impart mechanical stimuli to the plants, a phenomenon known as thigmomorphogenesis, where physical forces influence plant form and structure (Braam *et al.*, 2005). Continuous yet moderate mechanical stress can stimulate responses such as lignification and cell wall thickening, resulting in a robust stem structure. This adaptive response is evident in the significantly larger stem diameters seen in treatments like T₇, where the moderate mechanical stress helps improve resource support for overall growth.
- Chlorophyll Content and Photosynthesis:** Higher SPAD values in the T₈ Bower system, as well as in the T₇ and T₂ treatments, indicate a well-developed photosynthetic apparatus. With improved light exposure and reduced stress, plants can synthesize more chlorophyll. This increase in chlorophyll content not only reflects healthier leaves but also confirms that the biochemical pathways associated with photosynthesis are functioning more efficiently, which enhances the overall vigor and productivity of the plant (Li *et al.*, 2018).

Table 1: Effect of Different Training Systems in Passion Fruit (*Passiflora edulis*) under Prayagraj Agro-climatic region.

Sr.no.	Treatments no.	Treatment details	Control	Parameters			
				No. of leaves	Plant height	Stem girth	Chlorophyll content
1	T ₀	No system	Control	85.6	115	4.62	49.4
2	T ₁	Kniffin System	2 Arms	61	119	4.5	48.5
3	T ₂	Kniffin System	4 Arms	40.6	136.67	5.42	52.1
4	T ₃	High Trellis System	Single Cordon	79.3	142	5.13	45.3
5	T ₄	High Trellis System	Double Cordon	92.6	132	4.85	47.5
6	T ₅	Tatura	4 arms	45	144.67	4.12	49.4
7	T ₆	Tatura	8 Arms	120.6	142.3	4.61	47.9
8	T ₇	Bower System	2 Cordons	174	162	6.38	52.1
9	T ₈	Bower System	4 Cordons	160.3	169	5.9	52.4
F-test				S	S	S	S
S.Ed				20.9	12.14	0.27	2.55
CD at 5%				44.32	10.6	6.56	5.54
CV Value				26.36	25.75	0.57	6.33

Table 2: Cost of Different Training Systems in Passion Fruit (*Passiflora edulis*)

Cost of different training systems													
S.no.	Treatments no.	Treatment details	Control	No. of bamboos	Cost of bamboo (Rs. Per piece)	Total cost (in rupees)	Weight of Wire (in kg)	Cost of wire (per kg)	Total cost (in rupees)	Binding wire (in kg)	Cost of binding wire (per kg)	Total Cost (in rupees)	Total Cost of Treatment
1	T ₀	No system	Control	-	-	-	-	-	-	-	-	-	30,000
		Fertilization, irrigation, Labour charge											
2	T ₁	Kniffin System	2 Arms	600	60	36000	437	70	30625	1.1	70	77	66702
3	T ₂	Kniffin System	4 Arms	600	60	36000	916	70	64166	2.2	70	154	100320
4	T ₃	High Trellis System	Single Cordon	750	60	45000	250	70	17500	0.6	70	42	62542
5	T ₄	High Trellis System	Double Cordon	300	60	18000	458	70	32083	1.1	70	77	50160
6	T ₅	Tatura	4 arms	1150	60	69000	937	70	65625	2.25	70	157	134782
7	T ₆	Tatura	8 Arms	1500	60	90000	1875	70	131250	4.5	70	315	221565
8	T ₇	Bower System	2 Cordons	1050	60	63000	625	70	43750	1.5	70	105	106855
9	T ₈	Bower System	4 Cordons	1050	60	63000	895	70	62708	2.15	70	150	125858
												Total Cost	898784

Conclusion

Based on the investigation findings, the T₇ Bower system (2 Cordons) demonstrated the best performance, with 174 leaves, a vine length of 162 cm, a stem girth of 6.38 cm, and a chlorophyll content (SPAD value) of 52.1. Additionally, the T₄ High Trellis system (Double Cordon) was identified as the most cost-effective training system, costing Rs. 50,160/ ha.

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