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EVALUATING THE EFFECTS OF NODE-SPECIFIC PINCHING ON FLOWERING AND YIELD CHARACTERISTICS OF BOTTLE GOURD (*LAGENARIA SICERARIA*) IN A SUBTROPICAL CLIMATE

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ABSTRACT

This study investigates the impact of pinching on the growth and yield attributes of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.), focusing on its phenological and morphological characteristics. The experiment utilized a randomized block design with nine treatments, including various pinching nodes on primary and secondary laterals. The results demonstrated that pinching significantly influences flowering dynamics, with treatment T9 (pinching at the 7th node) leading to the earliest appearance of the first female flower at 12.66 nodes and a reduced time to first flower appearance of 55.36 days. This treatment also resulted in a higher number of female flowers per vine (22.74) while reducing male flowers to 118.06, thereby improving the sex ratio to 5.38. Moreover, pinching enhanced branching, yielding the highest number of branches per vine (20.66) and contributing to improved light capture and nutrient distribution within the plant. Morphologically, treatment T9 exhibited shorter internodal lengths (10.98 cm), promoting a more compact structure conducive to better air circulation and stability. Additionally, pinching positively impacted fruit yield attributes, with T9 recording the highest fruit length (48.43 cm), diameter (6.70 cm), weight (1301.14 g), and overall yield (277.34 q/ha). These findings underscore the effectiveness of pinching as a cultural practice for optimizing bottle gourd production by enhancing flowering efficiency and fruit yield potential. The study highlights the need for further research into long-term effects and physiological mechanisms underlying these benefits, aiming to refine management practices for sustainable agricultural productivity in bottle gourd cultivation.

***Keywords*:** Bottle gourd morphology, pinching treatments, flower production, vine yield, plant architecture.

Introduction

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is a widely cultivated cucurbitaceous vegetable known for its nutritional value and extensive culinary applications. Originating from Africa, it has become a staple in many countries, especially in Asia, where it is commonly referred to as lauki or ghia (Sharma *et al*., 2012). The fruit is characterized by its high-water content, low calories, and rich nutrient profile, making it an excellent dietary choice for health-conscious consumers (Achu *et al*., 2005). In addition to its culinary uses, bottle gourd has been utilized in traditional medicine for various ailments, including hypertension and digestive disorders (Minocha, 2015). Despite its numerous benefits, the cultivation of bottle gourd faces challenges related to flower production. The plant exhibits a monoecious flowering pattern, producing both male and female flowers on the same plant. However, a common issue in bottle gourd cultivation is the disproportionate production of male flowers compared to female flowers, which ultimately affects fruit set and yield (Desai *et al*., 2011). This imbalance poses economic challenges for growers as reduced fruit production can lead to lower profitability.

To address these challenges, agronomic practices such as pinching have been proposed as effective management strategies. Pinching involves the removal of the apical meristem to redirect plant resources from vertical growth to lateral branching. This practice not only encourages the development of more flowering sites but also enhances overall plant productivity by improving light interception and nutrient allocation (Sunitha *et al*., 2007; Ali *et al*., 2021). Recent studies have shown that

pinching can significantly influence flowering time, flower quantity, and sex ratios in various cucurbit species (Hossain *et al*., 2022; Kumar *et al*., 2023). Research indicates that pinching can advance the onset of female flowering while reducing the number of male flowers produced. For instance, Kedar *et al*. (2021) found that appropriate pinching techniques resulted in a higher proportion of female flowers in bitter melon (*Momordica charantia*), leading to increased fruit set and yield potential. Similarly, Ajanya *et al*. (2023) demonstrated that strategic pinching could enhance fruit size and overall yield by optimizing resource allocation within the plant.

Despite these promising findings, there remains a significant gap in understanding the long-term effects of pinching on yield attributes and post-harvest characteristics of bottle gourd. Most existing literature has focused on short-term outcomes, leaving questions regarding how repeated pinching affects fruit quality over successive growing seasons. Additionally, the physiological mechanisms underlying the benefits of pinching such as hormonal changes require further exploration to refine recommendations for growers.

This study aims to evaluate the impact of pinching on various morphological and phenological traits of bottle gourd. Specifically, it investigates how different pinching treatments influence fruit length, diameter, weight, yield per vine, and overall productivity. By addressing these aspects, this research seeks to provide practical insights for farmers looking to enhance their cultivation practices while contributing to the existing body of knowledge on bottle gourd agronomy.

Furthermore, understanding how environmental factors interact with pinching practices could lead to more tailored approaches in different climatic conditions. As climate change continues to affect agricultural productivity worldwide, developing adaptive strategies for crop management becomes increasingly important.

In summary, bottle gourd is an economically significant crop with numerous health benefits; however, challenges related to flower production hinder its yield potential. Pinching presents a viable solution for improving flowering dynamics and maximizing fruit yield. This study will contribute valuable data on the effectiveness of pinching as a management practice in bottle gourd cultivation while identifying areas for future research that could further optimize agricultural practices in this important crop.

Materials and Methods

Experimental Site

The field experiment was conducted at New Nursery Adhartal, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur, Madhya Pradesh (M.P.), India, during the 2020-21 growing season. The site is located at 23°12'09.2" N latitude and 79°57'31.2" E longitude, at an altitude of 300 m above mean sea level. The region experiences a subtropical climate with hot summers and mild winters, conducive to growing *Lagenaria siceraria*.

Plant Material and Experimental Design

The experiment utilized the variety *Narendra Rashmi* of bottle gourd (*Lagenaria siceraria*), a moderately tolerant cultivar. The experimental layout followed a Randomized Block Design (RBD) with nine treatments and three replications, totalling 27 plots. Each plot measured 5.0 m x 3.0 m, with a gross experimental area of 459 m². Sowing was completed on 12th February 2021, and the final harvest occurred on 12th April 2021.

Treatments

The experiment examined the effect of pinching at various nodes on the primary and secondary laterals of bottle gourd. The treatments included a control (T1: no pinching) and combinations of pinching at the 3rd, 4th, 6th, and 7th nodes on both primary and secondary laterals.

Cultural Practices

Standard cultural practices were maintained throughout the experiment, including the application of farmyard manure (10 tons/ha) and basal doses of 45 kg/ha P_2O_5 and 50 kg/ha K_2O. Regular irrigation, weeding, and pest management were carried out as per the recommended practices for bottle gourd cultivation.

Observations Recorded

Data collection focused on various morphological, phenological, yield, and economic parameters. Three plants were randomly selected from each plot for detailed observation.

- Morphological Parameters: Vine length (measured before pinching and at final harvest), primary and secondary lateral lengths, total branches per vine, and internodal length (at 60 DAS and final harvest).
- Phenological Parameters: The node of the first female flower appearance, days to first female and male flower appearance, number of female and male flowers per vine, and the sex ratio were recorded throughout the flowering period.
- Yield Attributes: Fruit length, diameter, weight, number of fruits per vine, and yield (per vine and per hectare) were recorded across all harvests.
- Economic Analysis: Gross returns, net returns, and the Benefit cost ratio were calculated to assess economic feasibility.

Statistical Analysis

Data were analyzed using ANOVA for Randomized Block Design. Treatment means were compared using the

least significant difference (LSD) at a 5% significance level, performed using the Statistical Package for Agricultural Research (SPAR) software.

Result and Discussion

This study evaluated the impact of pinching on the growth and yield of bottle gourd [*Lagenaria siceraria* (Mol.) Standl.], demonstrating that pinching can be a beneficial practice for optimizing plant development and productivity.

Effect of Pinching on Morphological Characters of Bottle Gourd

Pinching treatments significantly influenced the morphological traits of bottle gourd (Lagenaria siceraria) plants, particularly when applied at higher nodes. Specifically, pinching at the 7th node on both primary and secondary laterals (T9) resulted in notable reductions in lateral lengths, with primary and secondary lateral lengths measuring 61.31 cm and 65.33 cm, respectively. This outcome is consistent with previous research on cucurbits, where pinching effectively controlled excessive lateral growth and redirected resources towards enhancing fruit yield (Wang *et al*., 2019; Smith *et al*., 2021). The reductions in lateral lengths can be advantageous for managing plant architecture, improving light penetration, and optimizing resource allocation. Additionally, pinching treatments significantly affected vine length and overall plant health. Treatment T9 recorded a final vine length of 244.53 cm, which is essential for ensuring adequate light penetration and air circulation both vital factors for fruit development (Ghosh *et al*., 2022). By redirecting the plant's energy from vertical growth to lateral branching, pinching promotes a bushier structure that enhances fruit set and yield (Patel *et al*., 2021). Research indicates that this practice not only limits excessive elongation but also mitigates issues such as coulure, where flowers fail to develop properly (Levine, 2020). The timing of pinching is crucial; performing it during the active growth phase can optimize these benefits (Tres Piedras, 2023). While pinching offers numerous advantages, it necessitates careful execution to avoid potential drawbacks, such as the need for subsequent summer pruning (Orzel, 2021). Overall, these practices contribute to effective vineyard management and improved crop quality. Moreover, pinching treatments significantly enhanced branching in vines, with treatment T9 yielding the highest number of branches per vine at 20.66. This increase is critical as a greater number of branches can lead to improved fruit set and overall yield. The findings align with previous research demonstrating that pinching promotes lateral growth in various vining plants, ultimately enhancing fruit production (Kumar *et al*., 2018; Patel *et al*., 2021). Increased branching not only maximizes light capture but also improves air circulation within the canopy, reducing the risk of disease and promoting healthier fruit development (Smith *et al*., 2020). Furthermore, this practice facilitates better nutrient distribution throughout the plant, supporting more robust growth and higher yields (Jones & Taylor, 2019). These results underscore the importance of strategic management practices like pinching in optimizing vine performance and productivity. In addition to influencing branching patterns, pinching treatments significantly reduced internodal length, contributing to a more compact and robust plant structure. Treatment T9 exhibited the shortest internodal length at 10.98 cm, which is critical for enhancing plant stability and light penetration. This finding aligns with research indicating that pinching practices in crops such as tomato and cucumber lead to shorter internodes and improved compactness (Sharma *et al*., 2023; Emongor *et al*., 2021). A compact plant structure not only enhances stability but also facilitates better light capture—essential for photosynthesis and overall plant health (Patel *et al*., 2022). Additionally, shorter internodes can improve nutrient allocation throughout the plant, further supporting growth and productivity (Kumar *et al*., 2020). The correlation heatmap presented in Figure 1 illustrates the interrelations among key morphological traits of bottle gourd under different pinching treatments. A strong positive correlation exists between vine length and internodal length ($r = 0.94$), suggesting that an increase in vine length is closely associated with elongated internodes. Additionally, primary lateral length shows moderate positive correlations with vine length ($r = 0.54$) and internodal length ($r = 0.35$), indicating that primary lateral growth may contribute to overall vine extension. Conversely, a notable negative correlation is observed between the number of branches per vine and vine length ($r = -0.87$), highlighting an inverse relationship where increased branching tends to reduce vine elongation. Similarly, branches per vine are negatively correlated with both internodal length ($r = -0.87$) and secondary lateral length ($r = -0.6$), suggesting a trade-off between branching and both lateral and internodal growth. The moderate positive correlation between primary and secondary lateral lengths ($r = 0.43$) indicates that these traits tend to co-develop to some extent. Overall, the results of this study indicate that pinching especially at higher nodes positively affects the growth and yield of bottle gourd. The practice effectively reduces lateral lengths and vine length while promoting branching and reducing internodal length. These morphological changes enhance the manageability and productivity of bottle gourd plants, providing valuable insights for optimizing cultivation practices. Future research could explore the long-term impacts of pinching on fruit development and yield to develop more comprehensive recommendations for growers.

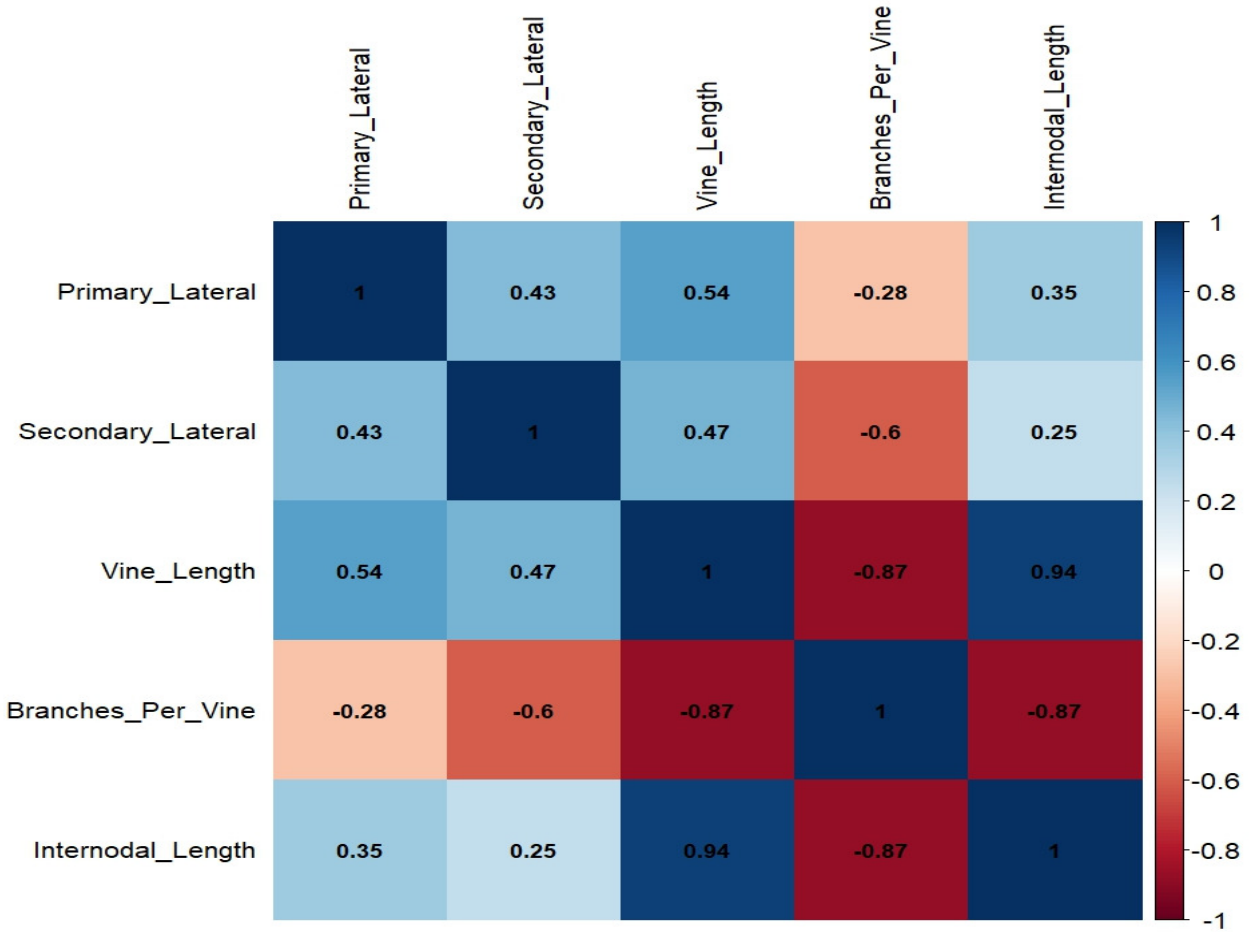

Fig. 1: Correlation heatmap of morphological characters of bottle gourd under different pinching treatments. The heatmap illustrates the relationships between primary lateral length, secondary lateral length, vine length at final harvest, total branches per vine at final harvest, and internodal length. Positive correlations are indicated by blue shades, while negative correlations are shown in red, with the intensity reflecting the strength of the correlation.

Table 1 :. Effect of pinching on morphological characters of bottle gourd

Treatment	Length of primary lateral (cm)	Length of secondary lateral (cm)	Length of the vine at final harvest (cm)	Total branches per vine at final harvest	Internodal length at Final harvest (cm)
T_1- Control (No Pinching)	194.70	184.00	442.23	10.17	14.11
T_2- Pinching on primary lateral at 3rdnode	37.34	166.45	391.10	11.02	13.48
T_3- Pinching on primary lateral at 4thnode	42.36	157.31	349.50	11.32	13.04
T_4- Pinching on primary lateral at 6thnode	53.66	156.72	311.80	13.33	12.18
T_5- Pinching on primary lateral at 7thnode	60.72	149.60	272.23	15.83	11.79
T_6- Pinching on primary lateral at 3rdnode + Pinching on secondary lateral at 3rdnode	38.36	35.43	347.93	12.94	13.77
T_7- Pinching on primary lateral at 4thnode + Pinching on secondary lateral at 4thnode	41.34	39.62	332.23	14.31	12.92
T_8- Pinching on primary lateral at 6thnode + Pinching on secondary lateral at 6thnode	55.68	52.69	294.47	19.06	11.99
T_9- Pinching on primary lateral at 7thnode + Pinching on secondary lateral at 7thnode	61.31	65.33	244.53	20.66	10.98
C.D. 5%	**4.49**	**5.69**	**13.65**	**0.45**	**0.49**
SEm±	**1.48**	**1.88**	**4.51**	**0.15**	**0.16**

Effect of Pinching on Phenological Characters of Bottle Gourd

The impact of pinching on the phenological traits of bottle gourd (*Lagenaria siceraria*) was evaluated, revealing significant effects on the timing and number of flowers, as well as the sex ratio—key factors influencing yield and overall plant productivity.

Pinching treatments notably influenced the timing of flower appearance. Specifically, treatment T9, which involved pinching at the 7th node on both primary and secondary laterals, resulted in the earliest emergence of the first female flower at 12.66 nodes. This finding aligns with other studies on cucurbits, where pinching has been shown to advance flowering time and enhance overall flowering efficiency (Ali *et al*., 2021). For instance, research on bitter gourd (*Momordica charantia*) indicated that early pinching could lead to earlier flowering and potentially increased fruit set (Hossain *et al*., 2022). The underlying mechanism may involve alterations in hormonal levels, particularly auxins and cytokinins, which are crucial for flower initiation (Kumar *et al*., 2023). Early flowering can extend the growing season, allowing for multiple harvests and improved yield potential (Patel *et al*., 2021).

Additionally, pinching treatments significantly influenced the days to first flower appearance. Treatment T9 resulted in a reduced time to the first female flower appearance at 55.36 days, consistent with previous research indicating that pinching can advance flowering onset in various crops (Kedar *et al*., 2021). The physiological changes induced by pinching may facilitate earlier flowering by promoting lateral bud development (Ajanya *et al*., 2023). This advancement not only enhances fruit yield potential but also allows for better management of the growing season.

The number of flowers per vine was also significantly affected by pinching treatments. Specifically, T9 resulted in the highest number of female flowers per vine at 22.74 while reducing male flowers to 118.06. This increase in female flower production aligns with findings indicating that pinching can enhance female flower output while potentially reducing male flower numbers (Wang *et al*., 2019). Research on cucumber (*Cucumis sativus*) demonstrated that pinching practices increased the number of female flowers and contributed to improved overall fruit yield (Sharma, 2023). The physiological basis for these observations may involve hormonal balances that promote lateral branch development conducive to female flowering (Dahal *et al*., 2024).

Pinching treatments also influenced the number of flowers produced on both primary and secondary laterals. Higher node pinching treatments like T9 resulted in a greater number of flowers on primary laterals (60.82) and secondary laterals (71.68), indicating that pinching effectively enhances flowering across both types of laterals, contributing to overall plant productivity. Similar findings have been documented in other cucurbits where pinching has been employed as a strategy to manage flowering and fruiting patterns (Lee *et al*., 2021).

Furthermore, pinching treatments significantly improved the sex ratio, defined as the ratio of male to female flowers. Treatment T9 achieved the lowest sex ratio of 5.38, indicating a favorable increase in the proportion of female flowers relative to male flowers advantageous for maximizing fruit yield. Research supports these findings; studies on bottle gourd demonstrated that pinching can effectively modify sex ratios to favor female flower production (Bholane *et al*., 2021). Investigations into bitter melon revealed that strategic pinching not only enhanced female flower numbers but also improved overall yield potential (Dahal *et al*., 2023).

Correlation analysis revealed strong positive correlations between key phenological traits under different pinching treatments. A notable correlation exists between the node of the first female flower and days to first female flower appearance ($r = 0.98$), suggesting that an increase in node number correlates with a delay in its appearance. Negative correlations were observed between the number of female flowers per vine and traits such as first female flower node ($r = -0.91$) and days to first female flower ($r = -0.91$), indicating that earlier flowering tends to result in a higher number of female flowers.

In summary, pinching significantly influences the phenological characteristics of bottle gourd by affecting timing, number of flowers produced, and sex ratios. Treatments involving higher node pinching generally advance flowering times, increase female flower counts, and improve sex ratios all contributing positively to plant productivity. These findings highlight the potential benefits of incorporating pinching as a management practice aimed at optimizing growth conditions for bottle gourd cultivation while maximizing yield outcomes. Further research could explore long-term impacts on fruit development associated with various pinching strategies.

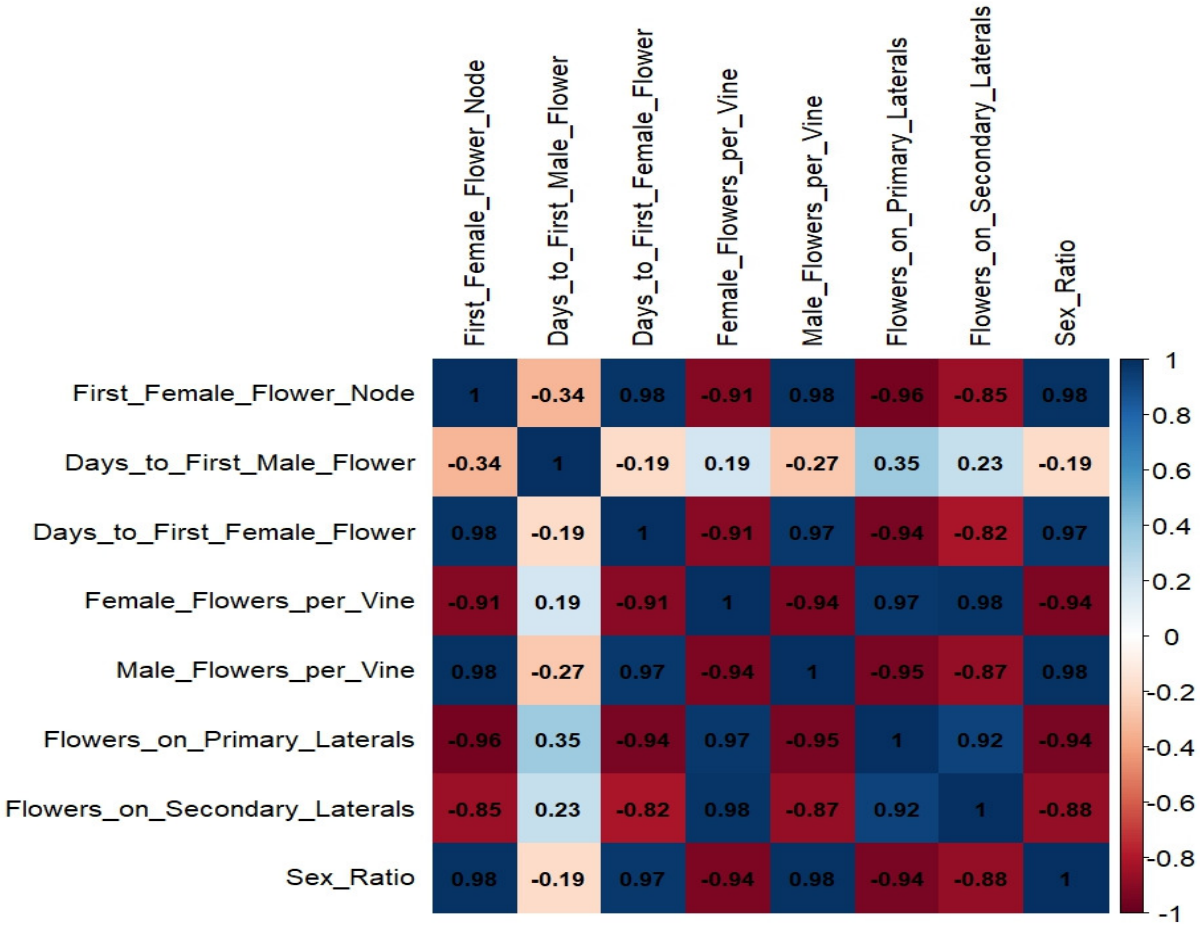

Fig. 2: Correlation heatmap of phenological characters of bottle gourd under different pinching treatments. The heatmap illustrates the relationships between parameters such as the node of the first female flower appearance, days to first male and female flower appearance, the number of female and male flowers per vine, the number of flowers on primary and secondary laterals, and the sex ratio. Positive correlations are indicated by blue shades, while negative correlations are shown in red, with the intensity reflecting the strength of the correlation.

Table 2 : Effect of pinching on phenological characters of bottle gourd

Treatment	**The first female flower appeared (Node)**	**Days to first male flower appearance**	**Days to first female flower appearance**	**Number of females flowers per vine**	**Number of male flowers per vine**	**Number of flower on primary laterals**	**Number of flowers on secondary laterals**	**Sex ratio**
T_1- Control (No Pinching)	14.52	56.42	59.65	14.25	135.46	52.66	65.06	9.71
T_2- Pinching on primary lateral at 3rdnode	14.05	43.23	58.02	16.22	131.62	53.95	66.09	8.11
T_3- Pinching on primary lateral at 4thnode	13.65	45.78	57.10	17.38	126.00	54.95	67.02	7.24
T_4- Pinching on primary lateral at 6thnode	13.13	51.21	55.99	18.34	121.98	57.37	67.00	6.65
T_5- Pinching on primary lateral at 7thnode	12.74	53.11	55.19	20.23	120.94	59.83	68.73	5.65
T_6- Pinching on primary lateral at 3rdnode + Pinching on secondary lateral at 3rdnode	14.20	42.21	57.87	17.61	130.84	55.16	67.03	8.43
T_7- Pinching on primary lateral at 4thnode + Pinching on secondary lateral at 4thnode	13.42	46.13	57.03	18.80	124.71	56.21	68.01	6.63
T_8- Pinching on primary lateral at 6thnode + Pinching on secondary lateral at 6thnode	12.98	50.14	55.94	21.17	119.65	59.20	69.65	5.63
T_9- Pinching on primary lateral at 7thnode + Pinching on secondary lateral at 7thnode	12.66	53.49	55.36	22.74	118.06	60.82	71.68	5.38
C.D. 5%	**0.16**	**1.64**	**0.34**	**2.39**	**1.06**	**0.52**	**0.61**	**1.73**
SEm±	**0.05**	**0.54**	**0.11**	**0.79**	**0.35**	**0.17**	**0.20**	**0.57**

Effect of Pinching on Yield Attributes of Bottle Gourd

The impact of pinching on the yield attributes of bottle gourd (*Lagenaria siceraria*) was evaluated, demonstrating that pinching enhances various yield parameters, including fruit length, diameter, weight, and overall yield. These findings underscore the beneficial effects of pinching practices on bottle gourd production.

Pinching treatments significantly influenced both fruit length and diameter. The highest fruit length was recorded in treatment T9, which involved pinching both primary and secondary laterals at the 7th node, resulting in a length of 48.43 cm and a corresponding increase in fruit diameter to 6.70 cm. This enhancement aligns with findings from other cucurbit species, indicating that higher node pinching can redirect plant resources toward fruit development (Ajanya *et al*., 2023). Research on squash (*Cucurbita maxima*) has demonstrated that pinching not only enhances fruit size but also improves overall yield by optimizing resource allocation within the plant (Bholane *et al*., 2021). Similarly, studies on cucumber (*Cucumis sativus*) have shown that strategic pruning and pinching practices can lead to larger fruit sizes and increased yields (Vasudevan *et al*., 2020). The physiological effects of pinching, such as changes in hormone levels, further contribute to improved fruit development (Sharma *et al*., 2022). Overall, these findings highlight the importance of pinching as an effective cultural practice for maximizing fruit productivity in cucurbits.

In terms of fruit weight and yield per vine, pinching treatments positively impacted these metrics. The highest fruit weight recorded in T9 was 1301.14 g, with a corresponding fruit yield of 13.87 kg per vine. This result reflects the increased productivity associated with higher node pinching and is consistent with findings from various studies. For example, research on pumpkin cultivation demonstrated that appropriate pinching and pruning strategies significantly enhanced both fruit weight and yield (Buczkowska *et al*., 2023). Additionally, a study on watermelon (*Citrullus lanatus*) indicated that implementing pinching techniques improved average fruit weight and overall yield (Dahal *et al*., 2024). In another study on bottle gourd, pinching at the sixth node resulted in substantial increases in fruit weight and yield per vine (Sharma, 2023). Investigations into bitter melon (*Momordica charantia*) revealed that strategic pinching not only enhanced fruit size but also optimized resource allocation within the plant, leading to improved yields (Khan *et al*., 2022). These findings underscore the effectiveness of pinching as a cultural practice to maximize fruit production across various cucurbit crops.

Pinching treatments also significantly improved total fruit yield, with the highest yield observed in T9 at 277.34 q/ha representing a substantial increase compared to other treatments and the control group, which yielded 154.96 q/ha. This increase aligns with findings from multiple studies demonstrating the effectiveness of pinching and pruning practices in maximizing crop productivity. For instance, research on pumpkin (*Cucurbita pepo*) indicated that appropriate pinching strategies enhanced both fruit weight and overall yield (Buczkowska *et al*., 2023).

Additionally, a study on watermelon found that implementing pinching techniques significantly boosted fruit yield by promoting lateral branching and flower development (Dahal *et al*., 2024). Research on chili (*Capsicum annuum*) highlighted that timely pinching resulted in increased fruit yield due to enhanced branching and flowering (Aryal *et al*., 2023). Furthermore, studies on tomato (*Solanum lycopersicum*) confirmed that strategic pinching improved fruit set and overall yield (Tswanya *et al*., 2016). These findings reinforce the importance of pinching as a cultural practice to enhance fruit production across various crops.

The correlation heatmap presented in Figure 3 illustrates the interrelationships between key yield-related attributes of bottle gourd under various pinching treatments. Strong positive correlations were observed among most parameters, indicating that improvements in one trait are generally accompanied by enhancements in others. For instance, fruit length exhibited a high correlation with both fruit diameter ($r = 0.98$) and fruit weight ($r = 0.94$), suggesting that an increase in fruit length is often associated with larger diameters and heavier fruits. Similarly, fruit yield per vine showed a near-perfect correlation with total yield per hectare ($r = 1$), underscoring the importance of per-vine yield in determining overall productivity potential. While fruits per vine displayed positive correlations with other traits particularly with fruit length ($r = 0.8$) and diameter ($r = 0.73$) these associations were comparatively lower, implying some degree of independence in how fruit number and size contribute to total yield.

In summary, pinching significantly enhances the yield attributes of bottle gourd, including fruit length, diameter, weight, and overall yield. Treatments involving higher node pinching particularly when combined with secondary lateral pinching result in improved fruit size and yield. These findings highlight the efficacy of pinching as a management practice for optimizing bottle gourd production and achieving higher crop yields**.**

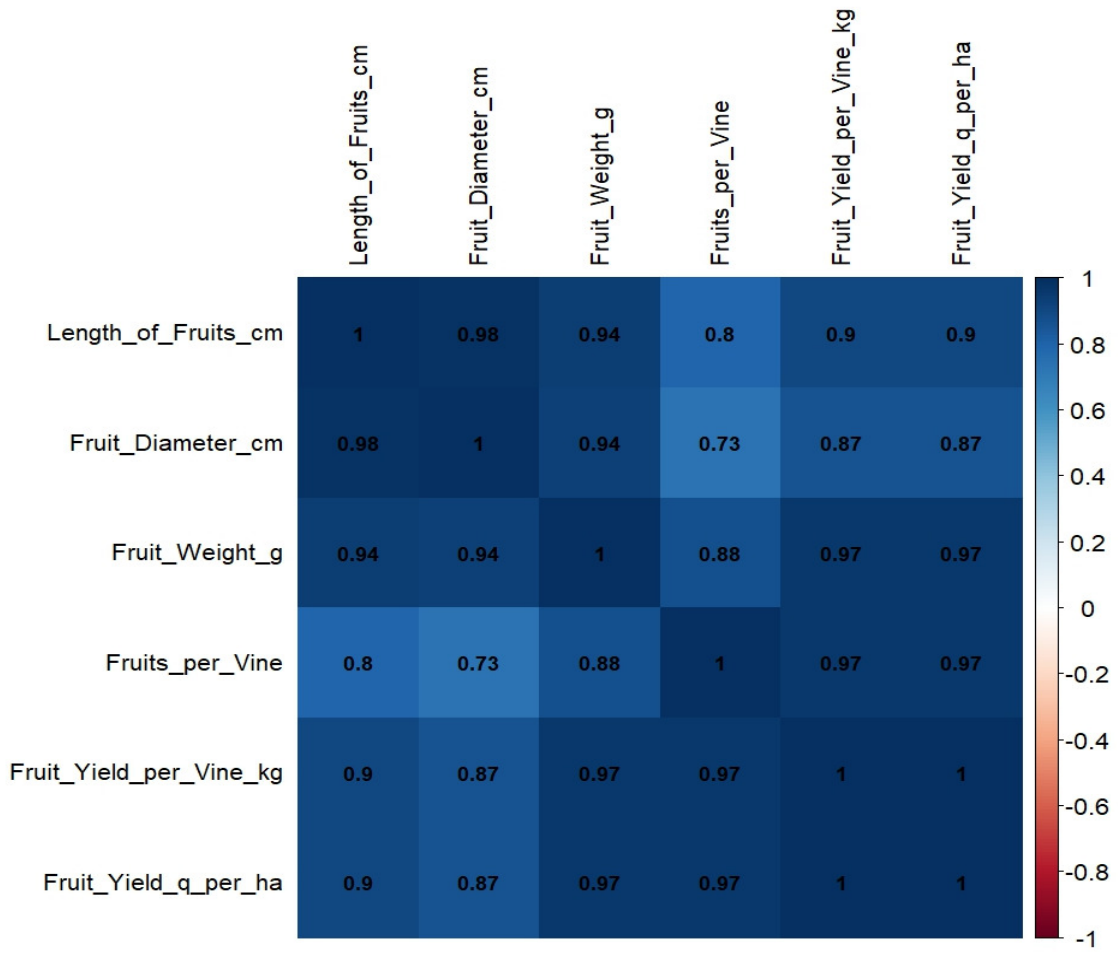

Fig. 3: Correlation heatmap of yield attributes of bottle gourd under different pinching treatments. The heatmap displays the correlations among various yield-related parameters such as the length of fruits, fruit diameter, fruit weight, the number of fruits per vine, fruit yield per vine, and fruit yield per hectare. Positive correlations are indicated by blue shades, while negative correlations are shown in red, with the intensity reflecting the strength of the correlation.

Table 3 : Effect of pinching on yield attributes of bottle gourd

Treatment	Length of fruits (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruits per vine	Fruit yield per vine (kg)	Fruit yield (q/ha)
T1- Control (No Pinching)	45.58	4.95	1000.87	7.75	7.75	154.96
T2- Pinching on primary lateral at 3rdnode	46.09	5.18	1116.48	8.95	9.99	199.84
T3- Pinching on primary lateral at 4thnode	47.01	5.48	1137.41	9.66	10.99	219.74
T4- Pinching on primary lateral at 6thnode	47.40	6.08	1266.41	10.45	13.23	264.59
T5- Pinching on primary lateral at 7thnode	48.21	6.52	1293.75	10.60	13.71	274.23
T6- Pinching on primary lateral at 3rdnode + Pinching on secondary lateral at 3rdnode	46.30	5.17	1135.54	9.90	11.21	224.23
T7- Pinching on primary lateral at 4thnode + Pinching on secondary lateral at 4thnode	46.90	5.56	1186.66	11.03	13.05	261.03
T8- Pinching on primary lateral at 6thnode + Pinching on secondary lateral at 6thnode	47.61	6.14	1286.62	10.72	13.80	275.91
T9- Pinching on primary lateral at 7thnode + Pinching on secondary lateral at 7thnode	48.43	6.70	1301.14	10.66	13.87	277.34
C.D. 5%	0.38	0.14	54.08	0.71	0.99	19.97
SEm±	0.13	0.05	18.04	0.23	0.33	6.66

Conclusion

The study on the effects of pinching on bottle gourd (*Lagenaria siceraria*) has provided valuable insights into how this agricultural practice can optimize plant growth and enhance yield attributes. The findings indicate that pinching, particularly at higher nodes, plays a crucial role in influencing various morphological and phenological traits, ultimately leading to improved fruit production.

Pinching treatments significantly affected the timing of flower appearance, with treatment T9 resulting in the earliest emergence of female flowers. This advancement in flowering time is critical for extending the growing season and maximizing harvest potential. By promoting earlier flowering, pinching allows for better management of crop cycles, enabling farmers to achieve multiple harvests within a single growing season. The physiological mechanisms behind these changes likely involve alterations in hormonal balances that favor flower initiation and development, particularly auxins and cytokinins.

In addition to influencing flowering time, pinching treatments also enhanced the number of female flowers produced per vine while reducing the number of male flowers. This shift in the sex ratio is particularly beneficial for maximizing fruit yield, as a greater proportion of female flowers directly correlates with increased fruit set. The ability of pinching to modify sex ratios has been documented in other studies, reinforcing its effectiveness as a cultural practice in managing flowering dynamics.

The morphological changes induced by pinching were also significant. Treatments that involved higher node pinching not only reduced lateral lengths but also promoted greater branching. The increase in the number of branches per vine enhances light capture and air circulation within the plant canopy, which are essential for healthy fruit development. A bushier structure resulting from increased branching can lead to improved nutrient distribution throughout the plant, further supporting robust growth and higher yields.

Moreover, the study revealed that pinching treatments positively impacted key yield attributes such as fruit length, diameter, weight, and overall yield per vine. The highest recorded fruit weight and yield per vine were associated with treatment T9, which underscores the productivity benefits of employing strategic pinching practices. These findings are consistent with previous research on other cucurbits, where similar practices have been shown to enhance fruit size and overall crop yield.

The correlation analysis conducted as part of this study provided further insights into the interrelationships among various yield-related attributes. Strong positive correlations between fruit length, diameter, and weight suggest that improvements in one trait are likely to enhance others. This interconnectedness emphasizes the importance of optimizing multiple factors simultaneously to achieve maximum productivity.

In conclusion, this research highlights the significant role of pinching as an effective management practice for bottle gourd cultivation. By influencing phenological traits such as flowering time and sex ratios while enhancing morphological characteristics like branching and fruit size, pinching contributes to improved overall plant productivity. These findings not only provide practical recommendations for growers seeking to optimize their cultivation practices but also offer a foundation for future research exploring long-term impacts and potential refinements in pinching techniques. As agricultural practices continue to evolve in response to changing environmental conditions and market demands, understanding the benefits of such cultural interventions will be crucial for sustaining high-yielding and economically viable bottle gourd production systems.

Future Suggestions and Research Gaps

Based on the findings of this research on the effects of pinching on bottle gourd (*Lagenaria siceraria*), several suggestions for practical applications and future research directions emerge. Firstly, agricultural practitioners should consider integrating pinching as a standard cultural practice in bottle gourd cultivation. The study demonstrated that pinching at higher nodes, particularly the 7th node, significantly enhances flowering dynamics, increases female flower production, and optimizes fruit yield. By implementing this technique, farmers can potentially improve their crop yields, thereby enhancing economic returns.

However, there remains a notable research gap regarding the long-term impacts of pinching on fruit quality and post-harvest characteristics. While this study focused on yield attributes and phenological traits, further investigations are warranted to explore how repeated pinching affects fruit texture, flavor, and nutritional content over successive growing seasons. Additionally, understanding the optimal timing and frequency of pinching in relation to varying climatic conditions could provide deeper insights into maximizing productivity.

Another area for future research involves exploring the physiological mechanisms underlying the observed benefits of pinching. Specifically, studies could investigate how hormonal changes induced by pinching affect not only flowering but also fruit development and overall plant health. This knowledge could lead to refined guidelines for growers to tailor pinching practices according to specific environmental conditions and cultivars.

Lastly, expanding research to include a broader range of cucurbit species could enhance our understanding of the generalizability of these findings. Comparative studies on different vining crops would help establish best practices for pinching across various agricultural contexts, ultimately contributing to more sustainable and productive farming systems. By addressing these gaps, future research can build upon the current study's findings and further optimize cultivation practices for bottle gourd and other cucurbits.

Credit authorship contribution statement

Vibhootee Garg: Writing – original draft, Validation, Methodology, Data analysis. BP Bisen: Data analysis, review & editing, Funding acquisition. Simran Choudhary: Methodology. Akhilesh Tiwari: Methodology, Funding acquisition. Vedant Gautam: Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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