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Effects of Different Types of Pinching in Growth and Yield of Two Varieties of Okra (*Abelmoschus esculentus* L.) in Pokhara, Kaski, Nepal

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ABSTRACT

This study was conducted in Pokhara, Kaski, Nepal in 2023 to investigate the effects of different pinching types and okra varieties on various growth and yield parameters. Treatments were arranged under a two-factor Randomized Complete Block Design (RCBD) with three replications. The treatments includes two okra varieties (Arka Anamika and Parbati) and 4 pinching types (apical bud pinching (P1), ABP along with 1 leaf pinching (P2), and ABP along with 2 leaf pinching (P3) and control (P4)). Parbati has exhibited a higher plant height (80.78 cm) than Arka Anamika (72.35 cm). Similarly, the P4 pinching type resulted in the tallest plant (85.91 cm). The P1 pinching type demonstrated the highest number of primary branches (4.87), while the control plots had the lowest (3.00). Arka Anamika showed a higher leaf count (40.77) than Parbati (37.19). Notably, the P1 recorded the highest leaf count (43.41), followed by P2 (37.19), with the control plots showing the lowest leaf count (32.76). The findings reveal the significant impact of pinching treatments on yield. Pinching type P1 produced the highest yield of 15.45 mt/ha, whereas the control group yielded the lowest at 9.31 mt/ha, which was comparable to the yield observed for pinching type P3 at 10.83 mt ha^{-1}. P1 also exhibited the highest number of pods per plant (15.90). Varieties and pinching methods exhibited notable interactions in average pod weight, diameter, and length. P1 displayed the widest pods (5.97 cm), whereas P2 had the longest (13.18 cm). Additionally, it can be noted that P3 yielded the heaviest pods at 16.16g when compared to P2, which yielded 14.09 g. Pinching treatments significantly influenced number of days to flowering, with P3 demonstrating the longest duration. Economic analysis was performed for evaluating technical efficiency, facilitating informed and sustainable decisions. Economically, P1 demonstrated superior performance, yielding a higher gross return of NPR 540,808.3, a net return of NPR 418,708.3, and a benefit-cost ratio of 4.43.

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Introduction

Okra (*Abelmoschus esculentus* L.) belonging to the family Malvaceae, is an important summer-season vegetable grown in Nepal (Maurya et al., 2013). It is majorly grown in Jhapa, Morang, Saptari, Dhanusha, Mohattari, Rautahat, Bara, Chitwan, and Kailali (Khanal et al., 2020). It is a popular vegetable majorly grown in tropical and subtropical regions, for its delicious and tender green fruits (Pandey et al., 2017). Okra is a vegetable that is low in calories and contains several essential vitamins and minerals. It contains about 33kcal, 7.45g carbohydrates, 1.48g sugars, 3.2g dietary fiber, and 2m proteins per 100g green pod of okra (Kumar et al., 2013). It also contains high fiber content that can help promote healthy digestion and has low cholesterol, reducing the risk of certain chronic diseases, such as heart disease (Gopalan et al., 1971; Kumar et al., 2009). Okra is effective in lowering blood sugar levels and helping those with diabetes. The fiber also aids in maintaining stable blood sugar levels by delaying the absorption of sugar via the intestines (Nguyen et al., 2009). Okra immature fruits, or green seed pods, are eaten as vegetables and can be used fresh or dried, fried or boiled in salads, soups, and stews (Ndunguru & Rajabu, 2004). Okra can be grown in different soil types, but high yields are achieved in well-drained, fertile soils with sufficient organic matter (Akinyele & Temikotan, 2007).

The growth, yield, and quality of okra are hindered by a lack of knowledge regarding optimal management practices and insufficient awareness of its nutritional and health benefits (Bake et al., 2017). Okra productivity in Nepal is 11.54 metric tons per ha (MoALD, 2021) which is lower than the production potential of the okra varieties.

Using low-yielding varieties, improper plant density, improper planting date, soil fertility, fertilizers, and attack of various insect pests, weeds, etc. all impacts vegetable production and productivity in all regions. Agricultural experts are working to formulate environmentally sustainable approaches to boost vegetable crop yields, considering that plant regulators and fertilizers have bad ecological impacts (Kattel et al., 2023). The use of plant regulators and fertilizers increases the cost of production. Therefore, improving cultural practices is crucial for enhancing productivity and the cost of cultivating okra. Besides various agronomic management practices like nutrient management, pinching is also an effective cultural management practice to improve productivity and economy.

Apical bud pinching is a common practice in vegetables like the okra plant which inhibits apical dominance, promotes lateral branch formation, and increases fruit per plant (Gujar & Srivastava, 1972). Apical dominance refers to the process by which the tip or apex of a shoot prevents the growth of secondary or lateral shoots (Cline, 1994). Studies suggest that the plant hormone auxin plays a role in apical dominance. When the apical tip is removed, the source of IAA is eliminated, leading to an increase in the outgrowth of lateral buds (Dun et al., 2006). According to the classical hypothesis, auxin along with secondary messenger, cytokinin regulates shoot branching (Li & Bangerth, 1999; Sachs & Thimann, 1967). The bud transition hypothesis suggests that the bud undergoes different developmental stages, each with varying sensitivity levels or response to long-distance signals, which may include auxin (Shimizu-Sato & Mori, 2001). Pinching is one such method that lets side branches grow by removing the apical buds and some leaves(Rajput et al., 2021). Benefits from pinching also include the management of plant diseases (Jyothi et al., 2018). This technique is commonly employed in various countries for certain okra and cucumber varieties (Kattel et al., 2023). By using this pruning technique, the yield of the plant can be increased (Cline, 1994). Pinching the apical tip of okra at an early stage of growth can increase growth and productivity because it allows enough time for the vegetative parts to regenerate and promotes more branches which increases photosynthetic activity and the accumulation of more photosynthates, thereby increasing seed size and yield (Lakshmi et al., 2015; Patil et al., 2012). Furthermore, pinching of okra 20 days after sowing recorded the highest seed germination, seedling length, and seedling vigor (Chauhan et al., 2022).

The responses of the various varieties to pinching may differ because of their distinct patterns of growth (Malshe & Pethe, 2020). Arka Anamika and Parbati varieties were selected as a recommendation of the National Agriculture Research Council (NARC) due to their adaptability and popularity (Yadav et al., 2023). Much research can be found about the effect of pinching in other vegetables and crops. However, there is limited scientific research on the effect of different types of pinching in okra. Similarly, there is a lack of studies related to the response of okra varieties to different types of pinching. Considering these factors, the study was conducted in Pokhara, Kaski to determine the effects of pinching methods on the growth and yield of okra and find the most responsive okra variety.

Materials and Methods

Experimental location

The experiment site was conducted at Pokhara, Kaski, Nepal from March to July 2023. It is located between 28.194° N latitudes and 84.004° E longitudes and was 822 meters above sea level. The soil property of the experimental site was sandy and alluvial soil with a slightly alkaline pH (7.2). The experimental site has been used for vegetable and rice production. Summer temperatures range between 25 and 35°C. Pokhara and its surrounding areas experience a lot of rain averaging around 4851 mm. The experimental site is illustrated in Figure 1. The meteorological data for Pokhara is depicted as provided by Power NASA in Figure 2.

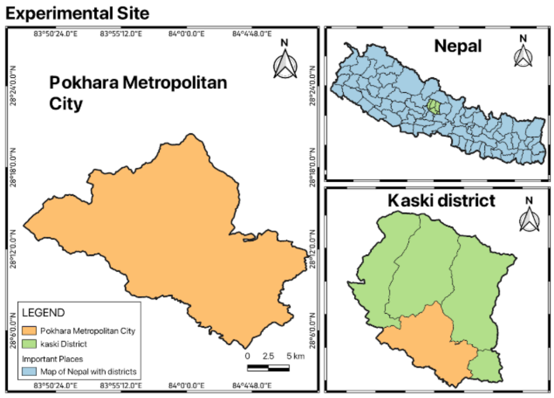

Figure 1. Experimental site

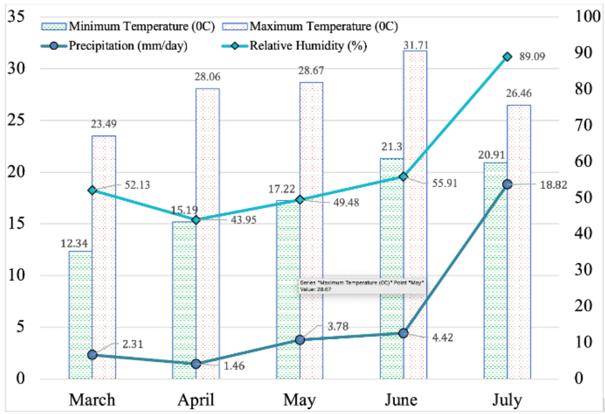

Figure 2. Climate chart of experimental site during study period

Experimental design and treatments

The research experiment was set up in a two-factorial Randomized Complete Block Design (RCBD) with three replications and eight treatments. Two okra varieties (Arka Anamika and Parbati) were used in the study. The plot size used was 1.5m * 2m. Row to row distance of 50 cm and Plant to Plant distance of 30 cm were maintained. Each plot had twenty plants maintained and a total of 24 plots in the study. From each plot, five plants were sampled. Land preparation was done by using power tillage and a raised bed was prepared by using helping hands. Sowing of seed was done on April 7, where row-to-row distance of 50 cm and plant-to-plant distance of 30 cm was maintained. The detail of treatment is shown in Table 1.

Table 1. Treatments details used during research process.

Varieties (Factor 1)	Pinching types (Factor 2)
V1 = Arka Anamika V2= Parbati	P1 = Apical Bud Pinching (ABP) P2 = ABP + 1 leaf pinching P3 = ABP + 2 leaf pinching P4 = Control
Treatments	**Combinations**
Treatment 1	V1P1
Treatment 2	V1P2
Treatment 3	V1P3
Treatment 4	V1P4
Treatment 5	V2P1
Treatment 6	V2P2
Treatment 7	V2P3
Treatment 8	V2P4

Plant Management Practices

Okra seeds to be sown were soaked overnight, treated with SAAF fungicide (Carbendazim 12% + Mancozeb 63% WP), and sown at a depth of 3-4 cm. The amount of fertilizer was calculated based on the recommended rate of NPK for okra in Nepal. 600 kg FYM per ropani, 6 kg Urea per ropani, 4 kg DAP per ropani, and 2kg MOP per ropani are recommended doses of NPK (MoALD, 2022). The full dose of DAP and MOP and a half dose of urea were applied at the time of sowing. The remaining dose of urea was top-dressed in two equal splits at 30 and 40 DAS. The various pinching treatments were manually performed 20 days after sowing. To improve the planting condition mulching was used to suppress weed growth reduce the amount of time and effort needed for manual weeding and improve soil moisture. Similarly, irrigation was given at 4-5 days intervals during summer and manual weeding was also done. Appropriate management and control techniques were used depending on the disease and pest affecting the plant. The field was treated with Noorani 505 (Chlorpyrifos 50% + Cypermethrin 5% EC) to manage jassid infestations.

Data Collection and Measurement

Various sample techniques were used to measure each crop's growth, yield, and yield components from each plot across the treatment level. Five plants from each plot were selected randomly and were marked as sample plants. The treatments were given 20 DAS (days after sowing) to each plot and vegetative data were collected every 10 DAT (days after treatment). The reproductive data were collected after flowering was observed. Harvesting was done at intervals of four days. The following parameters were studied during the study period.

Vegetative Parameters

Plant height (cm) was observed by measuring the length of the main stem from the base (the point of emergence of the plant to the top of the main stem on each sample pant with the help of a measuring scale. The number of leaves per plant was measured by counting the number of leaves (green leaves) excluding the dying yellow and emerging leaves from the sample plant. The number of branches per plant was measured by counting the number of branches from each sample plant. The vegetative parameter measurements were taken at 10-day intervals and were averaged for each day of observation.

Reproductive Parameters

Pod length (cm) was taken as the average fruit length measured with the help of a scale and rope. Pod diameter (cm) was obtained by calculating the circumference from the mid-length of each fruit with the help of rope and measuring scale. The number of fruits per plant was recorded as the average of the cumulative number of fruits in all picking of selected plants of a plot at the marketable stage for each treatment. The number of days to flowering was observed by counting days from the date of treatment to the first flowering appeared in each plot and the mean was recorded. Individual pod weight (g) of randomly selected pods in each treatment was measured with the help of highly precise electrical balance and the mean was calculated. Yield (mt ha^{-1}) was calculated by multiplying the fruit yield per plant by the total number of plants in one hectare.

Economic parameters

Cost of cultivation

All the cost of cultivation was worked out based on costs incurred according to the prevailing market price for different inputs, laborers, machines, fertilizers, and others. Only variable costs were included in the total costs section, for being a single-season crop.

Total cost = Cost of input × amount of input

Gross returns

The total monetary value of the okra on selling based on the prevalent average market was calculated.

Total income = P ×Y

Where, P = Rate/Farm gate price and Y = Yield

Net returns

Net returns (NRs. ha^{-1}) for each plot were calculated by deducting the cost of cultivation from the gross return obtained.

Net Profit = Gross Returns-Total Costs

Benefit-cost ratio

The benefit-cost ratio (B: C ratio) was calculated by dividing the gross return with the cost of cultivation. For a business to be feasible the B: C ratio of the business should be more than 1. If the BC ratio is less than 1, then the business is at a loss and the investor should not invest in that business.

Benefit Cost Ratio =Gross Returns/total cost

Statistical Analysis

Data collected from the sample plant was entered systemically in MS Excel (Office package 2016). Statistical test such as Analysis of Variance (ANOVA) was carried out by using R-studio (version 4.3.2). Mean comparison was done by using Duncan's Multiple Range Test (DMRT) to find out significant differences between the mean values at a 5% level of significance.

Results and Discussion

Vegetative Parameters

Various effects of treatments were observed for various vegetative parameters of okra. The result of the analysis of variance showed the following effects.

Plant Height

The effect of different pinching types and varieties on okra plant height is shown in Table 2. Plant height showed a significant difference for different pinching types except at 10 DAT whereas the difference was significant in varieties at 10 DAT ($p<0.01$) and 50 DAT ($p<0.05$). The highest height was observed in Parbati (80.78 cm) at 50 DAT. P4 pinching type (control plots) showed the highest plant height (85.91 cm) at 50 DAT ($p<0.05$). Similarly, the highest height was observed in control plots (P4) after 10 DAT, whereas at 50 DAT, P1 (75.35), P2 (73.68), and P3 (71.26) showed statistically similar plant height. The result suggests that the plant height slows down after pinching. This decrease in plant height is due to the redirection of auxin by pinching, which leads to the development of lateral branches and ultimately results in a decrease in the overall height of the plant (Deshmukh et al., 2022). A similar result was observed by (Sahu & Biswal, 2020) and (Ali et al., 2021) which also reported higher heights of okra plants that were not pinched. Results showed no significant interaction effect between different varieties and the pinching types for plant height. A similar result was reported by (Kattel et al., 2023).

Number of Leaves Per Plant

The number of leaves per plant was found to be significantly affected by varieties in all observations and pinching types in all observations except at 10 DAT (Table 3). Significant interaction among the varieties and pinching types was not observed for the number of leaves per plant. Arka Anamika showed a significantly higher number of leaves per plant than Parbati during all the observations. The highest number (40.77) of leaves per plant was observed in Arka Anamika at 50 DAT at ($p<0.001$) level of significance. After 20 DAT P1 pinching level (18.37) showed a significantly ($p < 0.05$) higher number of leaves which was statistically at par with P2 (16.12). The number of leaves was observed significantly ($p < 0.001$) higher in P1 (29.15) and a significantly ($p < 0.001$) lower number of leaves was observed in P4 (20.92) at 30 DAT. A similar result was also seen at 40 DAT. The highest number of leaves (43.41) was observed in the P1 pinching type and the lowest number of leaves (32.76) per plant was observed in the P4 pinching type at 50 DAT. Results suggested that control plots showed a lower number of leaves per plant compared to pinching treatment which was also observed in okra (Kattel et al., 2023) and (Sahu & Biswal, 2020). Similarly, pinching of the apical buds on the main stem of okra resulted significant increase in the number of leaves per plant and the leaf area (Rajappa et al., 2020). Employing the pinching technique increases the number of branches per plant, consequently resulting in a higher leaf count per plant in pinched plants which was also reported (Olasantan & Salau, 2008), in bottle gourd (AN et al., 2017) and field bean (Kumar et al., 2018).

Table 2. Effect of varieties and pinching types on plant height in okra

Treatments	Plant height(cm)				
	10 DAT	20 DAT	30 DAT	40 DAT	50 DAT
Varieties					
Arka Anamika	12.17^{b}	20.43	41.17	65.58	72.35^{b}
Parbati	14.30^{a}	20.63	41.59	69.98	80.78^{a}
LSD (0.05)	1.364	2.21	4.37	6.48	6.99
SEM (±)	0.45	0.73	1.44	2.14	2.30
F-Test	**	ns	ns	ns	*
Pinching types					
P1	13.04	19.71^{bc}	38.95^{b}	67.92^{b}	75.35^{b}
P2	12.44	21.15^{ab}	40.45^{b}	63.41^{b}	73.68^{b}
P3	13.09	17.71^{c}	37.49^{b}	60.01^{b}	71.26^{b}
P4	14.37	23.56^{a}	48.63^{a}	77.81^{a}	85.91^{a}
LSD (0.05)	1.92	3.13	6.18	9.17	9.88
SEM (±)	0.63	1.03	2.03	3.02	3.25
F-Test	ns	**	**	**	*
CV (%)	11.76	12.33	12.07	11.01	10.42

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 5% ($p<0.05$), **Significant at 1% ($p<0.01$),***Significant at 0.1% ($p<0.001$)

Table 3. Effect of varieties and pinching type on number of leaves per plant in okra

Treatments	Number of leaves				
	10DAT	20 DAT	30 DAT	40 DAT	50 DAT
Varieties					
Arka Anamika	8.94[a]	16.82[a]	25.89[a]	34.36[a]	40.77[a]
Parbati	7.67[b]	14.86[b]	22.76[b]	29.35[b]	37.19[b]
LSD (0.05)	0.89	1.87	1.99	2.29	2.86
SEM (±)	0.29	0.61	0.65	0.75	0.94
F- test	**	*	**	***	***
Pinching types					
P1	8.23	18.37[a]	29.15[a]	38.42[a]	43.41[a]
P2	8.11	16.12[ab]	24.43[b]	31.47[b]	37.19[b]
P3	7.67	15.07[b]	22.81[bc]	30.18[bc]	35.50[bc]
P4	9.12	13.81[b]	20.92[c]	26.98[c]	32.76[d]
LSD (0.05)	1.26	2.65	2.82	3.24	4.05
SEM (±)	0.42	0.87	0.93	1.06	1.33
F- Test	ns	*	***	***	***
CV (%)	12.27	13.52	9.38	8.82	8.79

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 5% (p<0.05), **Significant at 1% (p<0.01),***Significant at 0.1% (p<0.001)

Table 4. Effect of varieties and pinching type on number of primary branches in okra

Treatments	Number of primary branches				
	10DAT	20 DAT	30 DAT	40 DAT	50 DAT
Varieties					
Arka Anamika	1.24	1.90	3.09	3.77	4.22
Parbati	1.34	2.09	2.91	3.68	3.92
LSD (0.05)	0.32	0.34	0.43	0.51	0.58
SEM (±)	0.10	0.11	0.14	0.17	0.19
F- test	ns	ns	ns	ns	ns
Pinching types					
P1	2.05[a]	3.10[a]	3.85[a]	4.67[a]	4.87[a]
P2	1.62[a]	2.37[b]	3.32[ab]	3.89[b]	4.44[ab]
P3	1.08[b]	1.76[c]	3.0[b]	3.55[b]	3.97[b]
P4	0.40[c]	0.76[d]	1.87[c]	2.79[c]	3.00[c]
LSD (0.05)	0.45	0.48	0.61	0.72	0.81
SEM (±)	0.15	0.16	0.20	0.23	0.26
F- Test	***	***	***	***	**
CV (%)	28.35	19.45	16.52	15.73	16.16

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 5% (p<0.05), **Significant at 1% (p<0.01),***Significant at 0.1% (p<0.001)

Primary Branches Per Plant

The primary branch per plant was not found significantly affected by plant varieties. However, the primary branch per plant was found significantly affected by pinching types in all observations (Table 4). Significant interaction among the varieties and pinching types was not observed for the number of primary branches. The highest number (4.87) of primary branches was found in the P1 pinching type at (p<0.01) level of significance which was statistically at par with the P2 pinching type (4.44). The lowest number of primary branches (3.00) was found in the P4 pinching type (control plots) at 50 DAT. A similar type of observation was also seen in 10 DAT, 20 DAT, 30 DAT, and 40 DAT. The result of the analysis suggests that pinching promotes branches in pinched plants. A similar result was observed by (Rajappa et al., 2020) and (Deshmukh et al., 2022). The increase in the number of branches in pinched plants is primarily due to the reduction of apical dominance, which halts vertical growth and accelerates the development of productive branches. Consequently, this enhances photosynthetic activity, the accumulation of photosynthetic materials, and leads to increased fruit production and yield (Lakshmi et al., 2015). Similarly, significant differences were observed in the shoot branch and top fresh weight at different times of pinching in okra (Kim et al., 2015). Finally, a higher number of branches due to pinching was also reported in bottle gourds (AN et al., 2017) and marigolds (Abbas, 2018).

Reproductive data

Days to flowering

Days to flowering were found significant for different pinching types at (p< 0.01) level of significance but were not found significant for different varieties (Table 9). The analysis didn't show significant interaction between pinching types and two varieties for days to flowering. Arka Anamika and Parbati didn't show significant differences for days to flowering. The highest days to flowering (52.29 days) were observed for P2 (apical bud pinching and two leaf pinching) and the lowest days to flowering (43.62 days) were observed in P4 i.e. control plots. Results of the analysis suggested pinched plants exhibited delayed flowering, possibly because the removal of the apical portion hindered the process by removing the source of Indole 3-Acetic Acid (IAA). With lower concentrations of IAA, the initiation of lateral branches occurs which requires additional time to mature sufficiently for flowering to begin (Ali et al., 2021). The practice of pinching has previously been documented to cause delayed flowering in various crop species, such as carrots (Shah, 2019) and bottle gourd (AN et al., 2017).

Pod diameter (cm)

Pod diameter (cm) was found significant at ($p< 0.05$) level of significance for different varieties and was also significant at ($p< 0.001$) level of significance for different pinching types (Table 9). Parbati (5.59 cm) showed maximum pod diameter and Arka Anamika (5.30 cm) showed lowest pod diameter. This difference in average pod diameter in okra varieties might be due to variation in their genotype and their adaptability to environmental conditions. A similar type of result was observed in okra varieties (Dash & Rabbani, 2013). Similarly, the highest pod diameter (5.97 cm) was observed for P1 (apical bud pinching) whereas the lowest pod diameter (5.00 cm) was observed for P4 (non-pinched). The increase in pod diameter could be attributed to the greater presence of branches and leaves, along with the higher availability of photosynthates moving from the source to the sink (Shah, 2019). As a result of the pinching technique, a state of hormonal and nutritional equilibrium is achieved, resulting in the production of larger-sized fruits.

Significant interaction was observed at ($p < 0.05$) level of significance between varieties and pinching types for the average pod diameter (Table 5). The highest pod diameter was observed in Arka Anamika (5.91 cm) at the P1 pinching type which was seen as statistically similar to the P1 pinching type treatment in Parbati (6.04 cm). The lowest pod diameter was observed in Arka Anamika (4.64 cm) with P4 pinching type.

Pod length (cm)

Pod lengths were observed to be significant at ($P < 0.01$) level of significance for different varieties and were also observed to be significant at ($P < 0.05$) level of significance for different pinching types (Table 9). Arka Anamika (12.63 cm) showed the highest average pod length. The variation in average pod length among various okra varieties can be attributed to differences in their genetic characteristics and their varying ability to adapt to environmental conditions.

Table 5. Pod diameter as influenced by the interaction pinching types and varieties of okra

Treatments	Pod diameter (cm)			
	P1	P2	P3	P4
Arka Anamika	5.91^{a}	5.58^{ab}	5.07^{cd}	4.64^{d}
Parbati	6.04^{a}	5.30^{bc}	5.66^{ab}	5.37^{bc}
LSD(0.05)	0.42			
SE(±)	0.14			
F- Probability	*			
CV%	4.74			

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 5% ($p<0.05$), **Significant at 1% ($p<0.01$),***Significant at 0.1% ($p<0.001$)

Table 6. Pod length as influenced by the interaction of pinching types and varieties of okra

Treatments	Pod length (cm)			
	P1	P2	P2	P3
Arka Anamika	12.55^{b}	14.75^{a}	11.43^{bc}	11.80^{bc}
Parbati	11.78^{bc}	11.62^{bc}	11.47^{bc}	10.96^{c}
LSD(0.05)	1.17			
SE(±)	0.38			
F- Probability	*			
CV%	5.58			

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 5% ($p<0.05$), **Significant at 1% ($p<0.01$),***Significant at 0.1% ($p<0.001$)

Table 7. Individual pod weight as influenced by the interaction of pinching types and varieties of okra

Treatments	Individual pod weight (grams)			
	P1	P2	P2	P3
Arka Anamika	11.22^{c}	15.04^{ab}	17.93^{a}	10.53^{c}
Parbati	14.48^{b}	14.95^{ab}	14.04^{b}	12.36^{bc}
LSD(0.05)	2.97			
SE(±)	0.98			
F- Probability	*			
CV%	12.26			

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 5% ($p<0.05$), **Significant at 1% ($p<0.01$),***Significant at 0.1%($p<0.001$)

Table 8. Reproductive parameters as influenced by varieties and pinching types in okra

Treatments	Days to flowering	Pod Diameter (cm)	Pod Length(cm)	Pods/plant	Pod weight (g)	Yield (mt/ha)
Varieties						
Arka Anamika	48.04	5.30[b]	12.63[a]	11.86	13.68	10.90
Parbati	48.75	5.59[a]	11.46[b]	14.05	14.04	12.96
LSD (0.05)	2.76	0.21	0.58	2.29	1.48	2.88
SEM (±)	0.91	0.07	0.19	0.80	0.49	0.95
F-probability	ns	*	**	ns	ns	ns
Pinching types						
P1	47.67[b]	5.97[a]	12.17[b]	15.90[a]	12.83[b]	15.45[a]
P2	50.01[ab]	5.44[b]	13.18[a]	13.42[ab]	14.09[a]	12.14[ab]
P3	52.29[a]	5.36[b]	11.45[b]	11.55[b]	16.16[a]	10.83[b]
P4	43.62[c]	5.00[c]	11.38[b]	10.95[b]	11.44[b]	9.31[b]
LSD (0.05)	3.90	0.30	0.83	3.03	2.10	5.77
SEM (±)	1.28	0.10	0.27	1.14	0.69	1.34
F-Probability	**	***	*	*	**	*
CV (%)	6.51	4.74	5.58	21.57	12.26	27.64

Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT = Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, ns = non-significant and *Significant at 5% (p<0.05), **Significant at 1% (p<0.01),***Significant at 0.1%(p<0.001)

Table 9. Economic parameters as affected by pinching types and varieties of okra

Treatments	Total cost of cultivation (NPR ha^{-1})	Gross return (NPR ha^{-1})	Net return (NPR ha^{-1})	B:C ratio
Varieties				
Arka Anamika	122100	381791.7	259691.7	3.12
Parbati	122100	453658.3	331558.3	3.71
LSD (0.05)	0	101131.5	101131.5	0.82
SEM (±)	0	33341.66	33341.66	0.27
F-probability	ns	ns	ns	ns
Pinching types				
P1	122100	540808.3[a]	418708.3[a]	4.43[a]
P2	122100	425075.0[ab]	302975[ab]	3.48[ab]
P3	122100	379166.7[b]	257066.7[b]	3.10[b]
P4	122100	325850.0[b]	203750[b]	2.66[b]
LSD (0.05)	0	143021.5	143021.5	1.17
SEM (±)	0	47152.23	47152.23	0.38
F-Probability	ns	*	*	*
CV %	0	27.64	39.06	27.65

Note: 1USD (United States Dollars)= 134.29 NPR (August 12, 2024, exchange rate), Means followed by the same letter(s) in a column are not significantly different by LSD 0.05 level by DMRT. DAT= Days after Treatment, SEM (±) = Standard Error of Mean, LSD = Least Significant Difference, CV= Coefficient of Variance, NPR = Nepalese Rupee, ns = non-significant and *Significant at 5% (p<0.05), **Significant at 1% (p<0.01),***Significant at 0.1% (p<0.001)

Highest pod length (13.18 cm) was observed in P2 (apical bud + 1 leaf pinching). Pinched okra gave higher length fruits than non-pinched okra was also reported in okra (Kattel et al., 2023). The positive impact of pinching on pod size could be linked to the generation and movement of nutrients from the source to the sink and a higher number of leaves producing a higher amount of photosynthate, particularly carbohydrates which are transported to the sink, leading to the development of longer pods (Sowmya et al., 2017).

Significant interaction was observed at ($p < 0.05$) level of significance between varieties and pinching types for the average pod length (Table 6). Pod length as influenced by the interaction of varieties and pinching treatment was observed highest in Arka Anamika with P2 pinching treatment (14.75 cm) followed by P1 pinching treatment (12.55 cm). The lowest Pod length was seen in the interaction of Parbati and control pinching treatment (10.96 cm).

Pods per plant

Pods per plant were not observed to be significant between the two varieties but were observed to be significant at ($p < 0.05$) level of significance among different pinching types (Table 9). The highest pods per plant were observed in the P1 pinching type (15.90). A higher number of pods per plant was observed in pinched plots than in control plots. The same finding was reported by (Sahu & Biswal, 2020). Pinched plants exhibited a higher number of pods compared to those that were not pinched. Plants with an increased number of lateral branches displayed robust vegetative growth, leading to enhanced photosynthetic efficiency (Aikins et al., 2017). Similar to the results obtained in this research, the positive impact of pinching on reproductive growth has been noted in fenugreek (Vasudevan et al., 2008). The interaction between two varieties and four types of pinching did not show a significant interaction on the number of pods per plant.

Individual pod weight (g)

Individual pod weight (g) was observed to be significantly influenced by different pinching types at ($p < 0.01$) level of significance but was not observed significant difference among the two varieties (Table 9). The highest individual pod weight was observed in plots of the P3 pinching type (16.16 g) followed by the P2 pinching type (14.09 g). Mostly pinched plots gave higher average pod weight than non-pinched i.e. control plots. It was reported that in pinched plants, there is a greater presence of lateral branches, which are characterized by a higher leaf count and increased photosynthate production (Ali et al., 2021). The pinching technique results in the accumulation of more photosynthate in the sink, which is advantageous for producing heavier pea pods (Singh & Devi, 2006). Our findings were also consistent with the finding reported in Fenugreek by (Vasudevan et al., 2008). Similar beneficial effect was also observed in Okra (Sajjan et al., 2002). There was seen significant interaction at ($P < 0.05$) level of significance between varieties and pinching type for individual pod weight in okra Pokhara, Nepal 2023 (Table 7). The highest individual pod weight as influenced by okra varieties and pinching treatments was seen in Arka Anamika and P3 pinching treatment (17.93 g). The lowest individual pod weight was seen in Arka Anamika with P1 (11.22 g) which is seen statistically similar to Arka Anamika with P4 pinching treatment (10.53 g).

Yield (mt ha^{-1})

Yield (mt ha^{-1}) is found significantly influenced by different pinching methods but not significant in the case of variety (Table 9). The highest yield was observed in P1 i.e. Apical bud pinching (15.45 mt ha^{-1}) followed by P2 (12.14 mt ha^{-1}). The mean yield was observed at 11.93 mt ha^{-1}. Pinching causes the production of more lateral branches which increases photosynthesis and increases productivity. A similar result was observed in okra (Kattel et al., 2023) and by (Sahu & Biswal, 2020). Pinching techniques have previously been documented as advantageous for enhancing yield characteristics in various crop species like tomatoes (Tswanya & Olaniyi, 2016), bottle gourd (Naafe et al., 2022), and fenugreek (Sowmya et al., 2017).

Economic Analysis

The economic analysis was conducted by considering the production costs associated with each treatment, along with the resulting marketable yield at current unit prices.

Cost of Cultivation (NRs)

The cost of cultivation includes all the tentative working costs incurred in okra cultivation which was calculated in terms of cost per hectare. The cost of cultivation was similar for all the varieties and all the pinching types were NRs.122100ha^{-1}.

Gross Returns (NRs)

The overall financial worth of the primary product and any secondary products derived from the crop is referred to as gross return. This value was computed using the current average market conditions. Significant effect of pinching treatments in gross return but no significant effect of varieties on gross return was observed (Table 9). The highest gross return (NRs. 540808.3) was observed in P1 (apical bud pinching) closely followed by P2 (NRs.425075.0). Lowest gross return (NRs. 325850) was observed in P4 (control plots) which was statistically similar to other except P1 pinching type.

Net returns (NRs)

Net return is the gross return excluding the cost of cultivation. The table showed there was no significant difference in net return in varieties and showed a significant difference between different pinching treatments (Table 9). The highest net return (NRs. 4, 18,708) was observed in P1 closely followed by P2 pinching type (NRs. 3, 02,975). The lowest net return was observed in P4 (NRs. 2, 03,750) which was statistically similar to others except P1 pinching type.

Benefit-cost ratio (B: C ratio)

The benefit-cost ratio (B: C) is described as the return generated for each rupee invested. The B: C ratio was found significant for the pinching treatments and insignificant for the varieties (Table 9). The highest B: C ratio (4.43) was observed in the P1 pinching type closely followed by the P2 pinching type (3.48). The lowest net return (2.66) was observed in P4 (control plots) which was statistically similar to others except P1 pinching treatment.

Conclusion

The study brought some important information about the effect of different pinching types and varieties on the growth and yield of okra. Yield and yield-related parameters of okra were significantly affected by various pinching types. The application of the pinching treatment types mentioned increased the number of primary branches, total number of fruits per plant, and yield performance of okra. The application of pinching types or methods in two varieties of okra, Parbati showed higher plant height, and Arka Anamika showed a higher number of leaves but showed similar days to flowering, the total number of pods per plant, and yield. Economically two varieties also didn’t show any significant difference but showed significant differences for pinching types. Results revealed no variation among varieties for the productivity of okra. Based on the findings, the use of apical bud pinching on okra is recommended as a better practice than apical bud and leaf pinching to increase productivity.

Declarations

Author Contribution Statement

Prajjwal Koirala: Devised and designed the experiments; Performed the experiments; Analyzed and interpreted the data; materials, analysis tools or data; Wrote the paper.

Rijwan Sai: Analyzed and interpreted the data; materials, analysis tools, or data; Wrote the paper.

Pratikshya Subedi: Data collection; wrote the paper

Chiranjibi Khadka: Performed the experiments; Data collection; wrote the paper

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Declaration of Competing Interest

The authors declare no conflict of interest.

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