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Pruning and population density as smart solution to sustainable tomato production

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Abstract

The study evaluated the effects of pruning and plant spacing on tomato production from January 13 to April 13, 2025, in Salinungan West, San Mateo, Isabela. A Randomized Complete Block Design was used with two factors: Factor A (Pruning) – zero, three, four, and five branches; and Factor B (Spacing) – 75×30 cm, 75×40 cm, and 75×50 cm. Pruning had no impact regarding plant height at 30 and 60 days following transplanting (DAT) but pruning to four or five branches increased plant height at 90 DAT as well as the number of branches. Although pruning was unable to influence the total fruits produced per plant, five-branch pruning enhanced fruit diameter, fruit weight for each plant and total yield per hectare. Plants spaced at 75 × 30 cm were tallest at 30 DAT, but plant height was similar across all spacing treatments at 60 and 90 DAT. Wider spacing (75×50 cm) resulted in more fruits, larger fruit size, heavier fruit weight, and higher yield. No significant interaction was observed between pruning and spacing on plant height, number of branches, or fruit diameter. However, pruning to five branches, regardless of spacing, produced the heaviest fruit weight per plant and the highest yield per hectare.

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Introduction

Tomatoes hold significant importance globally due to their status as a staple crop and a vital component of human diets. Tomatoes, which are rich in nutrients like vitamins A and C, potassium, and antioxidants such as lycopene, offer health benefits including a reduced risk of heart disease and some types of cancer. Economically, they are among the most widely grown and traded vegetables worldwide, forming a critical source of income for millions of farmers. However, the global tomato industry faces numerous challenges, such as climate change, pest and disease outbreaks, and post-harvest losses, which threaten productivity and sustainability. Tomatoes are an essential vegetable in the Philippines, widely valued for their versatility in Filipino cuisine and their nutritional benefits. They are a key ingredient in many traditional dishes, such as sinigang, afritada, and menudo, providing flavor, color, and health benefits through their high content of vitamins A and C, potassium, and antioxidants like lycopene.

Pruning plays a vital role in optimizing tomato production by improving plant health, yield, and fruit quality. By selectively removing unnecessary or excess shoots, particularly suckers that grow in the leaf axils, pruning helps focus the plant's energy on fruit development rather than excessive vegetative growth. This practice improves air flow and light penetration, reducing blight risk and enhancing the plant's microclimate. Plant spacing is crucial for optimizing tomato production, as it directly affects plant health, yield, and fruit quality. Proper spacing ensures that each plant receives adequate light, water, and nutrients, which are essential for healthy growth and photosynthesis. Crowded plants compete for these resources, leading to reduced vigor, lower yields, and smaller fruits.

The interaction between pruning and spacing plays a crucial role in optimizing tomato production by influencing plant growth dynamics, disease management, and overall yield. Proper spacing ensures that each tomato plant has sufficient access to sunlight, nutrients, and air circulation, reducing competition and enhancing photosynthetic efficiency. When combined with strategic pruning, these benefits are amplified. Pruning reduces canopy density by removing unnecessary shoots, which, when paired with appropriate spacing, further improves light penetration and air movement within the plant structure. This synergy minimizes the risk of fungal diseases and pest infestations, common in densely packed or overgrown canopies.

An optimal spacing and strategic pruning enhance resource efficiency, ensuring better-quality fruit and higher yields. However, these practices must be carefully balanced according to the tomato variety and growing conditions to avoid stress or reduced productivity. Properly managed, the combination of plant density and pruning enhances both the economic and agronomic outcomes of tomato cultivation. Despite significant advancements, research gaps remain in understanding the optimal interaction between plant population density and pruning practices in tomato production, particularly under diverse environmental conditions and cultivation systems. Most existing studies focus on either density or pruning independently, with limited attention to their combined effects on different tomato varieties, including heirloom and modern hybrids. There is also a need for more research on how these practices influence long-term soil health, nutrient cycling, and microbial dynamics, especially in sustainable and organic farming systems.

Optimizing plant population density and implementing effective pruning practices in tomato production contribute significantly to achieving several Sustainable Development Goals (SDGs). These practices align closely with Zero Hunger by enhancing crop yields and improving fruit quality, ensuring a more efficient and sustainable food supply. By maximizing the use of available land and resources through proper spacing, farmers can increase productivity without expanding into natural ecosystems, supporting Life on Land and promoting biodiversity conservation. Additionally, improved air circulation and reduced disease incidence from strategic pruning minimize the need for chemical pesticides, contributing to Responsible Consumption and Production by fostering more sustainable agricultural practices. Enhanced resource efficiency from optimal plant density also reduces water and nutrient wastage, aligning with Clean Water and Sanitation. Furthermore, higher yields and better-quality produce can improve farmer incomes, supporting No Poverty and Decent Work and Economic Growth. Thus, sustainable tomato production practices involving proper density and pruning hold a key position in confronting global challenges, promoting environmental stewardship, and ensuring food security.

Materials and methods

Procurement of seeds and seedlings production

Hybrid seedlings of tomato (Diamante Max F1) were purchased from an accredited vegetable dealer of Ready to Plant Vegetable Seedling Specialist.

Experimental site

The experimental site was a well-drained soil and suited for tomato production

Soil Sampling and Analysis. Soil samples were collected prior to land preparation, air-dried, and ground to a fine texture, with any foreign materials removed. A one-kilogram composite sample was then transported to the DA CVIAL – Regional Soil Laboratory in Tuguegarao City for analysis. The soil nutrient levels, including key elements like nitrogen (N), phosphorus (P), and potassium (K), was assessed, which formed the basis for the fertilizer recommendations in the study.

Land preparation and experimental layout

The land was first plowed using a tractor, and then left fallow to enable weed decay and the germination of weed seeds before the final plowing. Afterward, final plowing and harrowing were performed in preparation for the experiment. The 414-square-meter area was then organized into three blocks, each measuring 3 meters by 23 meters, with a 1-meter pathway separating the blocks. Each block was subdivided into 12 plots, each 3 meters by 3 meters, with a 1-meter gap separating every six plots.

Experimental treatments and design

Two factors were used in the study following the different treatments, Factor A (Pruning): P1 – 0 (No Pruning), P2 – 3 Branches, P3 – 4 Branches and P4 – 5 Branches. Factor B (Plant Spacing/Plant Population): S1 – 75 cm x 30 cm (44,442 hills/ha), S2 – 75 cm x 40 cm (33,332 hills/ha) and S3 – 75 cm x 50 cm (26,666 hills/ha). The treatments were laid out using a Factorial Randomized Complete Block Design (RCBD) approach.

Application of fertilizers

Holes were dug following the spacing in the imposed treatments at 6 centimeters depth and 10 centimeters wide. The fertilizer rate, determined through soil analysis, served as the study's reference and was evenly distributed according to the number of hills per unit area.

Transplanting and replanting

A string with mark per treatment based on the distance per row was made before planting to have a uniform planting distance following the imposed treatments. One seedling was transplanted per hill. The base of the plants was covered with fine soil and pressed to have uniform germination and easy anchorage of the roots into the soil. Replanting of missing hills was done at 5 days after transplanting to have complete plant population per plot.

Time and sketch of pruning

In general, tomato plants produced main stems and main leaf branches. Fruit developed on the main leaf branches. The process typically focused on removing the side shoots or suckers that develop between the main stem and the leaf axils. The number of sideshoots or branches was done following the imposed treatments. The best time to prune tomatoes is early in the morning, as plants are less stressed during this period, and the wounds created by pruning have time to dry before nightfall, reducing the risk of fungal infections. Pruning was done when the first flowers started to open, removing the lower branches and the 2nd generation branches which is generally considered the standard practice, especially in commercial production.

Care and management

Cultivation, Weeding and Crop Protection. Manual weeding was done and hilling-up after side dressing. The occurrence of insect pests and diseases was monitored and recorded during the experimental period. It was controlled using chemical pesticides and fungicides following the dosage of the manufacturer's recommendation.

Water management

Surface irrigation system was used for the study. Watering the plants was done as the need arose.

Harvesting was done when the tomatoes reached physiological maturity; that is when they have developed to their full size and are capable of undergoing the normal ripening process, even if removed from the plant. This stage was marked by color change from green to red, fruit softening and the development of its taste and aroma.

Data gathered

The study assessed the impact of pruning, spacing, and their interaction on various parameters, this includes plant height at 30, 60, and 90 days after transplanting (in cm), number of branches per plant, number of fruits per plant, fruit diameter (in cm), fruit weight per plant (in grams), and fruit yield per 1,000 square meters (in kg). The collected data were analyzed through Analysis of Variance (ANOVA) based on a Factorial Randomized Complete Block Design, using the STAR (Statistical Tool for Agricultural Research) software. To further examine significant treatment differences, the Honestly Significant Difference (HSD) test was employed for mean comparison.

Results and discussion

Plant height (cm)

The height of tomato at 30, 60 and 90 days after transplanting as affected by pruning and spacing is presented in Table 1. The height of plants at 30 days after transplanting was not affected by pruning of branches which ranged from 67.91 to 68.66 centimeters. In terms of the effect of plant spacing on the height of plants at 30 DAT obtained significant result wherein the plants spaced at 75 cm x 30 cm (S_1) had the tallest with a mean of 70.93 centimeters while the plants 75 cm x 40 cm (S_2) and 75 cm x 50 cm (S_3) did not vary with each other with means of 67.95 and 66.02 centimeters. No significant result was noted on the interaction of pruning and spacing which they obtained heights from 65.25 to 72.00 centimeters. The height of plants at 60 days after transplanting showed no significant differences among treatments with means ranging from 94.28 to 96.39 centimeters. The different spacing did not also affect the height of plants which ranged from 94.37 to 95.50 centimeters. The height of plants showed no significant differences among treatment combinations. At 30 days after transplanting (DAT), plant height in tomato was significantly influenced by plant spacing, with closer spacing resulting in taller plants. This trend is often attributed to increased competition for light, which stimulates vertical growth as plants strive to outcompete neighbors for sunlight. According to Singh *et al.* (2018), densely spaced tomato plants exhibited increased stem elongation in response to limited light availability, a phenomenon known as shade avoidance. Similarly, research by Adekiya *et al.* (2020) demonstrated that narrow spacing leads to reduced lateral growth but enhanced vertical elongation due to inter-plant competition. This effect is especially pronounced during the early vegetative stage, such as at 30 DAT, when plants are rapidly developing their canopy structure. Therefore, while closer spacing may initially promote taller plants, it may also contribute to weaker stems and reduced air circulation, which could impact overall plant health in later growth stages. At 90 days after transplanting, significant result was obtained on the effect of pruning. Pruning of five branches (118.44 cm) and four branches (117.71cm) had tallest plants, while pruning of four branches was comparable when pruning three branches (117.58 cm) and zero pruning (117.31 cm) was done. The height of plants was comparable regardless of plant spacing where they obtained heights from 117.67 to 117.92 centimeters. No positive interaction was noted on the height of plants among the treatment combinations with 116.84 to 119.01 centimeters.

Table 1. Plant height (cm) of tomato as affected by pruning and population density

Treatments	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
Factor A (Pruning)			
P_1 – Zero Pruning	68.07	94.72	117.31b
P_2 – Three Branches	68.56	95.20	117.58b
P_3 – Four Branches	67.91	94.28	117.71ab
P_4 – Five Branches	68.66	96.39	118.44a
ANOVA result	ns	ns	*
Factor B (Spacing)			
S_1 – 75 cm x 30 cm	70.93a	95.50	117.67
S_2 – 75 cm x 40 cm	67.95b	94.37	117.92
S_3 – 75 cm x 50 cm	66.02b	95.17	117.70
ANOVA result	**	ns	ns
Factor A x B			
P_1S_1 – Zero Pruning x 75 cm x 30 cm	69.38	95.91	117.68
P_1S_2 – Zero Pruning x 75 cm x 40 cm	69.58	92.86	117.42
P_1S_3 – Zero Pruning x 75 cm x 50 cm	65.25	95.38	116.84
P_2S_1 – Three Branches x 75 cm x 30 cm	72.09	95.51	117.95
P_2S_2 – Three Branches x 75 cm x 40 cm	65.99	95.17	117.93
P_2S_3 – Three Branches x 75 cm x 50 cm	67.61	94.92	116.87
P_3S_1 – Four Branches x 75 cm x 30 cm	70.25	95.15	117.36
P_3S_2 – Four Branches x 75 cm x 40 cm	67.71	94.05	117.70
P_3S_3 – Four Branches x 75 cm x 50 cm	65.77	93.63	118.07
P_4S_1 – Five Branches x 75 cm x 30 cm	72.00	97.04	117.68
P_4S_2 – Five Branches x 75 cm x 40 cm	68.52	95.40	118.61
P_4S_3 – Five Branches x 75 cm x 50 cm	65.47	96.73	119.01
ANOVA result	ns	ns	ns
C.V. (%)	3.94	2.04	0.69

Note: Means with common letters are not significantly different with each other suing Honestly Significant Different (HSD) test, * -significant 5% level, ** - significant at 1% level , ns – not significant.

Number of branches

The number of branches of tomato as affected by pruning and population density is shown in Table 2. It was observed apparently that zero pruning (P_1) obtained the most number of branches per plant with a mean of 8.32. This was followed by pruning of three branches (P_2) with 7.10 and four branches (P_3) with 6.44. The least was observed from pruning of five branches (P_4) with a mean of 5.04. Pruning significantly influences the number of branches per tomato plant, as it directly involves the removal or restriction of lateral shoots, thereby influencing the plant's branching pattern and overall architecture. When tomato plants are pruned, especially through the removal of side shoots or suckers, the number of branches is intentionally reduced to encourage the plant to allocate more resources toward fruit development rather than vegetative growth. This is supported by the findings of Gebremariam *et al.* (2018) who reported that pruned tomato plants exhibited fewer branches compared to unpruned controls, leading to improved light penetration and air circulation within the canopy. Similarly, pruning significantly reduced the number of branches, which helped manage plant height and improved fruit quality and yield. These studies highlight pruning as a key cultural practice in managing branch proliferation, which is particularly beneficial in high-density planting systems or protected cultivation where space and airflow are critical. The plant spacing did not show any significant effect on the number of branches per plant with mean values ranging from 6.69 to 6.76. Likewise, the interaction of pruning and plant spacing did not affect the number of branches with means ranging from 5.00 to 8.40.

Table 2. Number of branches per plant as affected by pruning and population density

Treatments	Number of branches per plant
Factor A (Pruning)	
P_1 – Zero Pruning	8.32a
P_2 – Three Branches	7.10b
P_3 – Four Branches	6.44c
P_4 – Five Branches	5.04d
ANOVA result	**
Factor B (Spacing)	
S_1 – 75 cm x 30 cm	6.76
S_2 – 75 cm x 40 cm	6.69
S_3 – 75 cm x 50 cm	6.73
ANOVA result	ns
Factor A x B	
P_1S_1 – Zero Pruning x 75 cm x 30 cm	8.40
P_1S_2 – Zero Pruning x 75 cm x 40 cm	8.27
P_1S_3 – Zero Pruning x 75 cm x 50 cm	8.30
P_2S_1 – Three Branches x 75 cm x 30 cm	7.27
P_2S_2 – Three Branches x 75 cm x 40 cm	6.97
P_2S_3 – Three Branches x 75 cm x 50 cm	7.07
P_3S_1 – Four Branches x 75 cm x 30 cm	6.43
P_3S_2 – Four Branches x 75 cm x 40 cm	6.40
P_3S_3 – Four Branches x 75 cm x 50 cm	6.50
P_4S_1 – Five Branches x 75 cm x 30 cm	5.00
P_4S_2 – Five Branches x 75 cm x 40 cm	5.10
P_4S_3 – Five Branches x 75 cm x 50 cm	5.03
ANOVA result	ns
C.V. (%)	3.07

Note: Means with common letters are not significantly different with each other suing Honestly Significant Different (HSD) test, ** - significant at 1% level, ns – not significant.

Number of fruits

Table 3 shows the number of fruits per plant as affected by pruning and plant spacing. Data showed that pruning of branches in tomato did not affect the number of fruits per plant. It means that pruning of three to five branches produced comparable number of fruits to that of the zero pruning with means ranging from 29.58 to 32.35. Significant result was obtained on the effect of spacing on the number of fruits per plant. It was observed that plants spaced at 75 cm x 50 cm (S_3) produced the most number of fruits per plant with a mean of 37.10. This was followed by the plants spaced at 75 cm x 40 cm (S_2) with a mean of 31.35. The least was observed in plants spaced by 75 cm x 30 cm (S_1) with a mean of 26.28 fruits. Tomato plants grown at closer spacing have been found to produce a higher number of fruits per unit area compared to those planted at wider intervals. This increase in fruit production is largely attributed to the higher plant population density, which maximizes land use efficiency and increases the total number of fruit-bearing plants within a given area. According to Adekiya *et al.* (2020), closer spacing significantly enhanced fruit yield, even though individual plant productivity was sometimes slightly lower, due to inter-plant competition. Similarly, Patil *et al.* (2018) reported that tomatoes planted at narrow spacings produced more fruits overall, owing to the cumulative contribution of more plants occupying the same land area. The interaction between pruning and spacing significantly influenced the number of fruits per plant as revealed by the analysis of variance. Among the treatment combinations, the greatest number of fruits per plant (40.33) was recorded in plants that received no pruning and were spaced at 75 cm × 50 cm (P_1S_3), which was statistically similar to several other high-yielding combinations, including three branches at 75 cm × 50 cm (36.87), four branches at the same spacing (39.30), and five branches at 75 cm × 40 cm (30.67) and 75 cm × 50 cm (31.90). These results suggest that wider spacing, particularly 50 cm, consistently supports greater fruit production regardless of the pruning level. Conversely, closer spacing (30 cm) generally resulted in fewer fruits, with the lowest yield recorded in four branches at 75 cm × 30 cm (24.87), significantly different from the highest values. Notably, the effect of pruning was also evident, as moderate pruning levels (three to five branches) tended to perform better than zero pruning at closer spacing but were outperformed at wider spacing. This indicates that optimal fruit production is achieved through a strategic combination of proper pruning and sufficient spacing, highlighting a positive interaction between these two factors. A study by Maboko and Du Plooy (2018) revealed that lower plant densities (16,000 plants per hectare) without stem pruning resulted in higher marketable yields per plant and per hectare. Conversely, higher densities led to decreased fruit numbers per plant, although total yield per area remained unaffected. This suggests that reduced competition at lower densities allows for better resource allocation, enhancing fruit production per plant. Similarly, research conducted in Shewarobit, Central Ethiopia, indicated that closer inter row spacing (60 cm) significantly increased marketable fruit yield by 50% compared to wider spacing (120 cm). The study emphasized that optimal spacing minimizes competition for light, nutrients, and water, thereby promoting better fruit development (Warner *et al.*, 2024). Pruning practices also play a crucial role in fruit yield. A study on cherry tomatoes demonstrated that plants pruned to retain more branches produced a higher number of fruits per plant. Specifically, unpruned plants or those pruned to two branches yielded more fruits compared to single-stemmed plants, highlighting the importance of pruning intensity in maximizing fruit production. Furthermore, dynamic plant spacing strategies have been explored to mitigate the reduction in fruit quality associated with high planting densities. High-density planting increased total yield per area. It resulted in smaller fruit size and lower fruit weight per plant. Implementing dynamic spacing allowed for high yields while maintaining better fruit quality (Zhang *et al.*, 2024).

Fruit diameter (cm)

The fruit diameter of tomato as affected by pruning and population density is presented in Table 4. The fruit diameter was significantly affected by pruning whereby pruning of five branches (P_4) produced biggest fruit diameter with a mean of 4.86 centimeters. This was followed by pruning four branches (P_3) and five branches (P_2) with comparable means with of 4.51 and 4.56 centimeters. The smallest fruits were observed in Zero Pruning (P_1) with a mean of 4.21 centimeters. This result of the study implies that increased pruning of branches in tomato plants has been shown to positively affect fruit diameter, often resulting in larger, more uniform fruits. By removing excess lateral shoots, pruning reduces competition for nutrients and photosynthates, allowing the plant to allocate more resources to fruit development rather than vegetative growth. According to Gebremariam *et al.* (2018), tomato plants subjected to more intensive pruning produced fruits with significantly larger diameters compared to minimally pruned or unpruned plants. This enhancement in fruit size is attributed to improved light penetration and better air circulation, which support efficient photosynthesis that may otherwise affect fruit quality. Similarly, Motsa *et al.* (2019) reported that pruning to a limited number of main stems resulted in fewer fruits per plant but with increased average fruit diameter, indicating a shift in the plant's resource allocation strategy. These findings suggest that while more pruning may reduce the total number of fruits, it can enhance fruit quality by increasing size. No significant interaction of pruning and spacing in fruit diameter of tomato was found regardless of treatment combinations which range from 4.12 to 5.02 centimeters.

Table 3. Number of fruits per plant as affected by pruning and population density

Treatments	Number of fruits per plant
Factor A (Pruning)	
P_1 – Zero Pruning	32.23
P_2 – Three Branches	32.35
P_3 – Four Branches	32.15
P_4 – Five Branches	29.58
ANOVA result	ns
Factor B (Spacing)	
S_1 – 75 cm x 30 cm	26.28c
S_2 – 75 cm x 40 cm	31.35b
S_3 – 75 cm x 50 cm	37.10a
ANOVA result	**
Factor A x B	
P_1S_1 – Zero Pruning x 75 cm x 30 cm	26.87b
P_1S_2 – Zero Pruning x 75 cm x 40 cm	29.50b
P_1S_3 – Zero Pruning x 75 cm x 50 cm	40.33a
P_2S_1 – Three Branches x 75 cm x 30 cm	27.20b
P_2S_2 – Three Branches x 75 cm x 40 cm	32.97a
P_2S_3 – Three Branches x 75 cm x 50 cm	36.87a
P_3S_1 – Four Branches x 75 cm x 30 cm	24.87c
P_3S_2 – Four Branches x 75 cm x 40 cm	32.27b
P_3S_3 – Four Branches x 75 cm x 50 cm	39.30a
P_4S_1 – Five Branches x 75 cm x 30 cm	26.17b
P_4S_2 – Five Branches x 75 cm x 40 cm	30.67a
P_4S_3 – Five Branches x 75 cm x 50 cm	31.90a
ANOVA result	*
C.V. (%)	8.12

Note: Means with common letters are not significantly different with each other suing Honestly Significant Different (HSD) test, * - significant at 5% level, ** - significant at 1% level, ns – not significant.

Table 4. Fruit diameter (cm) as affected by pruning and population density

Treatments	Fruit diameter (cm)
Factor A (Pruning)	
P_1 – Zero Pruning	4.21c
P_2 – Three Branches	4.51b
P_3 – Four Branches	4.56b
P_4 – Five Branches	4.86a
ANOVA result	**
Factor B (Spacing)	
S_1 – 75 cm x 30 cm	4.46b
S_2 – 75 cm x 40 cm	4.51b
S_3 – 75 cm x 50 cm	4.64a
ANOVA result	*
Factor A x B	
P_1S_1 – Zero Pruning x 75 cm x 30 cm	4.12
P_1S_2 – Zero Pruning x 75 cm x 40 cm	4.15
P_1S_3 – Zero Pruning x 75 cm x 50 cm	4.37
P_2S_1 – Three Branches x 75 cm x 30 cm	4.46
P_2S_2 – Three Branches x 75 cm x 40 cm	4.46
P_2S_3 – Three Branches x 75 cm x 50 cm	4.60
P_3S_1 – Four Branches x 75 cm x 30 cm	4.55
P_3S_2 – Four Branches x 75 cm x 40 cm	4.57
P_3S_3 – Four Branches x 75 cm x 50 cm	4.57
P_4S_1 – Five Branches x 75 cm x 30 cm	4.70
P_4S_2 – Five Branches x 75 cm x 40 cm	4.86
P_4S_3 – Five Branches x 75 cm x 50 cm	5.02
ANOVA result	ns
C.V. (%)	3.11

Note: Means with common letters are not significantly different with each other suing Honestly Significant Different (HSD) test, * - significant at 5% level, ** - significant at 1% level, ns – not significant.

Weight of fruits per plant (g)

The fruit weight per plant as affected by pruning and spacing is presented in Table 5. Significant fruit weight was observed in pruning of five branches (P_4) with a mean of 2085.78 grams. This was followed by pruning of four branches (P_3) with a mean of 1651.33 grams, three branches (P_2) with 1395.89 grams and the least was obtained in zero pruning with a mean of 1100.67 grams. This result implies that increased pruning of branches in tomato plants has been found to significantly influence fruit weight, generally leading to heavier individual fruits. This effect is primarily due to the reduction in vegetative competition within the plant, allowing more resources such as water, nutrients, and carbohydrates to be directed toward fruit development rather than the growth of excessive foliage. According to Tesfaye *et al.* (2017), tomato plants that underwent more frequent or intensive pruning produced fruits with greater average weight compared to less-pruned or unpruned plants. This is supported by the findings of Hossain *et al.* (2020), who observed that pruning enhanced fruit weight by improving light distribution within the canopy and facilitating better nutrient allocation. Although increased pruning might lower the total number of fruits per plant, it typically enhances fruit quality characteristics like weight and size.

Table 5. Weight of fruits per plant (g) as affected by pruning and population density

Treatments	Weight of fruits per plant (g)
Factor A (Pruning)	
P_1 – Zero Pruning	1100.67d
P_2 – Three Branches	1395.89c
P_3 – Four Branches	1651.33b
P_4 – Five Branches	2085.78a
ANOVA result	**
Factor B (Spacing)	
S_1 – 75 cm x 30 cm	1497.92b
S_2 – 75 cm x 40 cm	1543.42a
S_3 – 75 cm x 50 cm	1633.92a
ANOVA result	**
Factor A x B	
P_1S_1 – Zero Pruning x 75 cm x 30 cm	1122.00d
P_1S_2 – Zero Pruning x 75 cm x 40 cm	1063.33d
P_1S_3 – Zero Pruning x 75 cm x 50 cm	1116.67d
P_2S_1 – Three Branches x 75 cm x 30 cm	1373.00c
P_2S_2 – Three Branches x 75 cm x 40 cm	1379.33c
P_2S_3 – Three Branches x 75 cm x 50 cm	1435.33c
P_3S_1 – Four Branches x 75 cm x 30 cm	1550.00b
P_3S_2 – Four Branches x 75 cm x 40 cm	1652.33b
P_3S_3 – Four Branches x 75 cm x 50 cm	1751.67b
P_4S_1 – Five Branches x 75 cm x 30 cm	1946.67a
P_4S_2 – Five Branches x 75 cm x 40 cm	2078.67a
P_4S_3 – Five Branches x 75 cm x 50 cm	2232.00a
ANOVA result	**
C.V. (%)	3.23

Note: Means with common letters are not significantly different with each other suing Honestly Significant Different (HSD) test, ** - significant at 1% level.

The spacing significantly affected the weight of fruits per plant where plants spaced by 75 cm x 50 cm and 75 cm x 40 cm had heaviest fruits with means of 1633.92 and 1543.42 grams while the plants spaced by 75 cm x 30 cm produced least fruit weight of 1497.92 grams. The spacing between plants significantly impacts the fruit weight of tomatoes by affecting the availability of light, nutrients, and water for each plant. Wider spacing usually provides plants with greater access to these resources, minimizing competition and promoting the growth of larger, heavier fruits. According to Patil *et al.* (2018), tomato plants spaced at wider intervals produced significantly heavier fruits compared to those planted more closely, due to enhanced light penetration and nutrient uptake. Similarly, Adekiya *et al.* (2020)

reported that increasing plant spacing led to an improvement in fruit weight, as plants were less crowded and could allocate more assimilates to fruit growth rather than competing for survival. The combined effect of pruning level and plant spacing significantly influenced the fruit weight per plant. The highest fruit weights were recorded in the five branches pruning treatments where P_4S_3 (75 cm x 50 cm) yielded 2232.00 g, followed by P_4S_2 (2078.67 g) and P_4S_1 (1946.67 g). These were followed by the four branches treatments, P_3S_3 (1751.67 g), P_3S_2 (1652.33 g) and P_3S_1 (1550.00 g). The three branches treatments produced moderate weights in P_2S_3 (1435.33 g), P_2S_2 (1379.33 g) and P_2S_1 (1373.00 g). The lowest fruit weights were observed in the zero pruning treatments, the P_1S_1 (1122.00 g), P_1S_3 (1116.67 g), and P_1S_2 (1063.33 g). The connection between pruning intensity and plant spacing showed a considerable impact on tomato plant weight and yield, suggesting that wider spacing paired with proper pruning techniques can improve fruit size and overall productivity. For example, Ara et al. (2007) found that two-stem pruning combined with a wider spacing of 50 cm produced the highest marketable yield of 97.08 t/ha, demonstrating the synergistic influence of these factors on tomato yield. These results highlight the importance of considering both pruning and spacing together to optimize tomato plant weight and yield.

Table 6. Yield per hectare (tons) as affected by pruning and population density

Treatments	Yield per hectare (tons)
Factor A (Pruning)	
P_1 – Zero Pruning	30.67d
P_2 – Three Branches	38.08c
P_3 – Four Branches	45.94b
P_4 – Five Branches	56.08a
ANOVA result	**
Factor B (Spacing)	
S_1 – 75 cm x 30 cm	41.00b
S_2 – 75 cm x 40 cm	42.48a
S_3 – 75 cm x 50 cm	44.60a
ANOVA result	**
Factor A x B	
P_1S_1 – Zero Pruning x 75 cm x 30 cm	30.46d
P_1S_2 – Zero Pruning x 75 cm x 40 cm	30.09d
P_1S_3 – Zero Pruning x 75 cm x 50 cm	31.46d
P_2S_1 – Three Branches x 75 cm x 30 cm	37.44c
P_2S_2 – Three Branches x 75 cm x 40 cm	37.46c
P_2S_3 – Three Branches x 75 cm x 50 cm	39.33c
P_3S_1 – Four Branches x 75 cm x 30 cm	43.94b
P_3S_2 – Four Branches x 75 cm x 40 cm	45.94b
P_3S_3 – Four Branches x 75 cm x 50 cm	47.95b
P_4S_1 – Five Branches x 75 cm x 30 cm	52.15a
P_4S_2 – Five Branches x 75 cm x 40 cm	56.41a
P_4S_3 – Five Branches x 75 cm x 50 cm	59.67a
ANOVA result	*
C.V. (%)	3.31

Note: Means with common letters are not significantly different with each other suing Honestly Significant Different (HSD) test, * - significant at 5% level .

Yield per hectare (tons)

The fruit yield per hectare as affected by pruning and spacing is presented in Table 6. The yield per hectare was significantly affected by pruning. The pruning of five branches (P_4) obtained the highest yield with 56.08 tons. This was followed by pruning of four branches (P_3) with 45.94 tons, pruning of three branches (P_2) with 38.08 tons and the least was obtained in zero pruning (P_1) with a mean of 30.67 tons. Spacing had a significant impact on fruit yield per hectare, with plants spaced at 75 cm x 50 cm and 75 cm x 40 cm producing the heaviest fruits, averaging 44.60 and 42.48 tons respectively, whereas plants spaced at 75 cm x 30 cm yielded the least fruit weight of 41.00 tons. Additionally, the interaction between pruning and plant spacing significantly affected the yield per hectare. The highest yields were recorded in the five branches pruning treatments in which P_4S_3 (75 cm x 50 cm) produced 59.67 tons/ha, followed by P_4S_2 (75 cm x 40 cm) with 56.41 tons/ha and P_4S_1 (75 cm x 30 cm) with 52.15 tons/ha. These were followed by the four branches treatments, P_3S_3 (47.95 tons/ha), P_3S_2 (45.94 tons/ha), and P_3S_1 (43.94 tons/ha). The three branches treatments yielded moderately in P_2S_1, P_2S_2, and P_2S_3 producing 37.44, 37.46 and 37.44 tons/ha, respectively. The lowest yields were observed in the unpruned (zero pruning) treatments with P_1S_3 (31.46 tons/ha), P_1S_1 (30.46 tons/ha), and P_1S_2 (30.09 tons/ha). The combined effect of pruning and plant spacing plays a significant role in tomato fruit yield, as these factors affect the plant's capacity to capture light, absorb nutrients, and sustain an ideal canopy structure. Pruning, particularly the removal of lateral shoots or suckers, directs the plant's energy toward fruit development rather than excessive vegetative growth. When coupled with appropriate spacing, it enhances air flow and light penetration, which can reduce disease incidence and improve photosynthetic efficiency, ultimately boosting fruit yield. According to Olasantan (2007), tomato plants that were pruned and spaced at wider intervals (60 cm and above) produced significantly higher yields per plant due to improved growth conditions and reduced intra-specific competition. However, while wider spacing favors individual plant yield, it may reduce yield per hectare if too much ground space is underutilized. Therefore, balancing plant density with pruning is key to optimizing total fruit yield per area. Naika *et al.* (2005) found that moderate spacing (around 50 cm) combined with single-stem pruning increased marketable fruit yield due to enhanced fruit size and lower disease pressure. Similarly, studies by Peet and Welles (2005) highlighted that strategic pruning paired with proper plant spacing can lead to more uniform fruit development and higher overall yield under both open-field and greenhouse conditions. These findings suggest that an integrated approach, adjusting pruning methods in relation to spacing density, is critical to achieving maximum fruit yield in tomato cultivation.

Conclusion

In conclusion from the results of the study, pruning of five branches could increase fruit yield of tomato. Additionally, planting tomatoes with a spacing of either 75 cm x 40 cm or 75 cm x 50 cm is suitable for tomato production.

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