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Growth Response of Peach (*Prunus persica* L.) Var. "Tropic Beauty" to Intra-Row Spacing and Blended NPS Fertilizer Rate

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Abstract

Peach fruit has been cultivated in Ethiopia, using poor production technologies such as unspecified population density and fertilizer application. Accordingly, this study was conducted to evaluate the effect of intra-row spacing and blended NPS fertilizer rate on the growth performance of peach trees. Peach variety "Tropic Beauty" seedlings were planted in 2017 using a completely randomized block design with factorial arrangement and replicated thrice. The treatments used were three levels of intra-row spacing (4m, 5m, and 6m) and four levels of NPS fertilizer rates (0kg/ha, 100kg/ha,150kg/ha, and 200kg/ha) with a constant inter-row spacing of 4 m. Data on the growth parameters were collected for four consecutive years. The result indicated that the interaction of intra-row spacing and NPS fertilizer rate had a highly significant ($p< 0.01$) effect on most growth traits. Amongst, tree height (2.66 m), trunk cross-sectional area (31.44 cm^2), canopy volume (11.74 m^3), and canopy stretch (3.46 m) were superior in the intra-row spacing of 6 m and 150 kg/ha NPS fertilizer rate. Conversely, intra-row spacing of 5 m and 150 kg/ha NPS fertilizer and intra-row spacing of 6 m without NPS fertilizer resulted in the highest branching height (59.42 cm) and annual shoot growth (34.13 cm), respectively. This indicated that intra-row spacing of 6 m with 150kg/ha NPS fertilizer rate could enhance the growth and development of peach trees.

Keywords: fertilizer; growth; intra-row; performance; spacing

Introduction

Vegetative and reproductive growth often occurs concurrently in perennial crops. Due to that, resources are not sufficient to support maximum growth rates. This results in competition for resources; and is agreed to be the basis for partitioning resources into reproductive and vegetative organs (Ho *et al*. 1989; Wardlaw, 1990). Particularly, in fruit cultivation, it is essential to maintain a balance between vegetative growth and fruiting (Huett, 1996). Studies have also revealed that models of peach fruit growth and plant development have identified useful principles for assisting growers in making horticultural management decisions (Naor *et al*. 2001). Perhaps, early estimation of blooming and harvest date, fruit development, and fruit quality attributes can help growers plan crop management practices efficiently (Lopez *et al*. 2007; Day *et al*. 2008).

Fertilization is one of the key activities that directly influence the optimum output of peach plantations by maintaining the overall plant development. It is the main way to ensure the normal growth and development of trees, and improve fruit quality (Zhang *et al*. 2022). In many crops, it is the basic practice affecting the plant physiology in different ways depending on the form (Lobit *et al*. 2001), the amount of the nutrient applied (Jordan *et al*. 2014), and the timing of applications (Niederholzer *et al*. 2001). Moreover, the application of fertilizer has numerous advantages such as reducing soil pH, increasing nutrient availability, reducing soil salinity, enhancing soil fertility, water retention, and soil organic matter, as well as increasing biological activity of microflora, soil cation exchange, natural hormones and antibiotics (Nijjar, 1985). Despite that, several factors can affect the plants' nutritional levels such as rainfall, fruit load, pruning, rootstock, nutritional interactions, and pesticide applications (Heckman, 2001). On the other hand, the level of fertilizer application can be reduced without negative impacts on peach tree growth during the initial years of field establishment (Casamali *et al*. 2021). Its increased application frequency ensures adequate mineral nutrients for peach growth (Wert *et al*. 2009).

Orchards designed with high tree density can only produce high early yields per unit area resulting in early returns on invested capital (Phillips and Weaver, 1975). Increasing tree planting density has been the most important means of increasing young orchards' early yield and early light interception (Sansavini and Corelli-Grappadelli, 1997). However, excessive planting density can lead to light competition and reduced photosynthesis and consequently lower peach quality (Anthony and Minas, 2021). These orchards become more uneconomic than standard orchards probably because of tree size, high or uncontrolled competition for resources, internal shading, barrenness, and poor manageability (Hayden and Emerson, 1973; Boswell *et al*. 1975). Besides, aged high-density orchards may pose serious problems for canopy management and ultimately increase the associated costs (DeJong *et al*. 1999).

Several studies on population density and fertilization of peaches have been reported worldwide. For example, the fertilizer and liming standards for Rio Grande do Sul and Santa Catarina suggest applying 20 to 80 kg ha^{-1} N per year for populations of up to 400 plants per hectare (Ferreira *et al*. 2018). However, the effect of fertilizer application and population density on the growth, yield, and quality are also dependent on climatic factors and management practices. Nevertheless, such types of research were lacking; and information is unavailable, particularly in Ethiopia, where peach farming has been practiced for a long time. Therefore, the objective of this study was to evaluate the effect of intra-row spacing and NPS fertilizer rate on the growth performance of peach trees.

Materials and Methods

Experimental site description

The field trial was conducted at Holetta Agricultural Research Center, central highlands of Ethiopia, located at 9° 00’ N latitude, 38° 30' E longitude, and with an elevation of 2400 masl. The area received an average annual rainfall of 1236.9 mm and a relative humidity of 68.4 percent. The average annual minimum and maximum temperatures were 7.3 and 23.5 °C, respectively during the experimentation (Figure 1). The dominant soil type of the experimental site is Eutric Nitisols (Fekadu and Geremew, 2021).

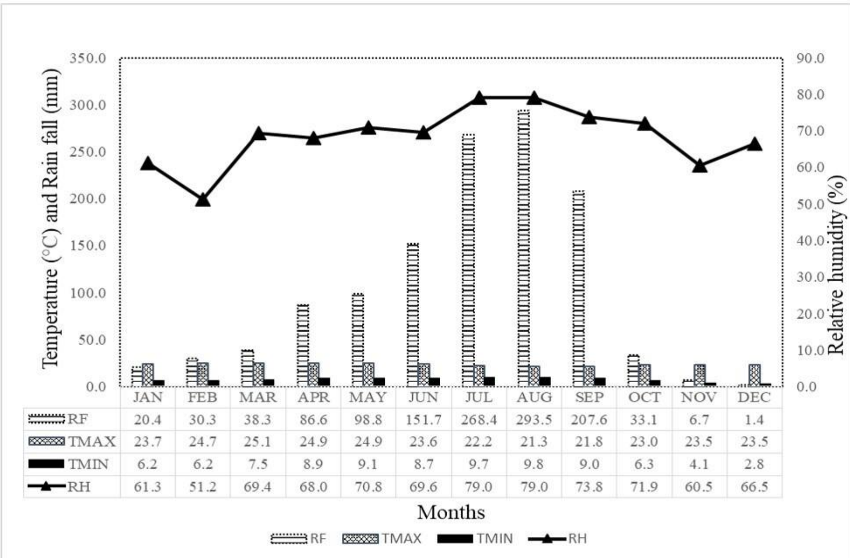

Figure 1. Climatic data of Holeta Agricultural Research Center metrology station (2017-2021)

Treatment setup

Seedlings of the peach variety “Tropic Beauty” with more or less uniform stand were established in 2017 using a factorial arranged randomized complete block design with three replications. The treatments comprised three levels of intra-row spacing (4 m, 5 m, and, 6 m) and four different rates of NPS fertilizer (0 kg/ha, 100 kg/ha, 150 kg/ha, and 200 kg/ha) with a constant inter-row spacing of 4 m for all treatments. All the field management practices like irrigation, weeding, disease and pest management, open center pruning, and training were performed equally.

Data collection

Soil samples from all plots of each replication were taken before fertilizer application at 0-30 cm depth using augur. Then the collected samples were composited and bulked into one sample for each replication. The bulked samples were air-dried and ground to pass a 2 mm sieve for soil Physico-chemical quality laboratory analysis. Similarly, after fertilizer application, four soil samples were taken from each tree per plot and bulked into one sample per plot. Then, the samples were air-dried and taken to the laboratory for soil Physico-chemical quality analysis. The pH was measured following the 1:2.5 H_2O method whereas phosphorous and total nitrogen were analyzed following the methods of Bray II (Khalid *et al*. 1977) and Kjeldhal (Bremner and Mulvaney, 1982), respectively. On the other hand, soil textural (sand, silt, and clay) analysis was done by following the hydrometric method (Bowen, 2022).

Data were recorded on growth characteristics such as tree height (m), branching height (m), annual shoot growth (cm), trunk cross-sectional area (cm^2), canopy volume (m^3), and canopy stretch (m). The tree height was measured from ground level to the longest shoot of the tree using a height meter. The branching height was also measured from the ground level to the emergence point of the first scaffold branch. Whereas, four shoots representing the current season's growth were chosen, and the average was used as an annual shoot growth. Besides, the trunk diameter was measured by using a vernier caliper, 10 cm above the graft union, and the result was used to calculate the trunk cross-sectional area using the equation of Westwood *et al*. (1963).

$$TCSA = \frac{\pi D^2}{4}$$

Where, π = 3.14; TCSA = trunk cross-sectional area in cm^2; D = trunk diameter above the graft union in centimeters.

The canopy spread was also measured in north-to-south and east-to-west directions by using a height meter and the result was used to calculate the canopy volume (Thorne *et al*. 2002).

$$V = \frac{2\pi}{3} H(\frac{A}{2}\ X \frac{B}{2})$$

Where π = 3.14; v = volume in m^3; A = canopy spread in the north to south direction in m; B = canopy spread in the east to west direction in m; and H = height of the tree in m. Finally, the mean tree canopy stretch was calculated using North-South and East-West spreading of branches as follows (Liu *et al*. 2021).

$$canopy\ stretch\ (m) = \frac{DNS + DEW}{2}$$

Where DNS = the canopy width in the north-to-south direction; and DEW = the canopy width in the east-to-west direction.

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using SAS version 9.3 (SAS, 2017) and interpretations were made following the procedure of Gomez and Gomez (1984). The mean separation was done using the Least Significance Difference test at a 5% level of significance.

Results and Discussion

Soil properties

The experimental soil had a proportion of 7.75% sand, 27.25% silt, and 65% clay, which was classified as clay according to the soil texture triangle while the soil's pH was 6.4 which was grouped as acidic (Table 1). The soils with pH values ranging from 6.73 to 7.3 are considered neutral soils (Tekalign, 1991). The soil comprised a total of 0.155% N, and thus the composite soil sample of the experimental area was rated as low (London, 1991). The experimental soil contains an available P of 7.596 ppm, which could also be grouped as a low level (Olson *et al.* 1954).

Table 1 Soil characteristics of the experimental field before fertilizer application

Soil parameters	Unit	Value
Sand	%	7.75
Silt	%	27.25
Clay	%	65
pH	-	6.4
Available phosphorous	ppm	7.596
Total nitrogen	%	0.155

The soil chemical characteristics after NPS fertilizer application have been presented in Table 2. Accordingly, the soil pH was decreased after fertilizer application for most of the treatments regardless of a slight increment on 5 m intra-row spacing without NPS fertilizer, intra-row spacing of 6 m without NPS fertilizer, and intra-row spacing of 4 m with 150 kg/ha NPS fertilizer. This implies that fertilizer application had increased the soil acidity. This however was not beyond the normal soil pH range of 6-7 required for peach production (Kamas *et al*. 2013). Whereas, the available phosphorous showed a slight increment in all treatments except untreated trees. When the amount of NPS fertilizer application increased, the rate of available phosphorous also increased but it might harm its effectiveness if its amount is beyond the required level (Taylor and Issell, 1971). Similarly, total nitrogen was increased after fertilizer application for all treatments, except in intra-row spacing of 4 m with 200 kg/ha NPS fertilizer.

Table 2. Soil characteristics of experimental plots after fertilizer application

Treatments		pH	P (ppm)	N (%)
Spacing (m)	NPS (kg/ha)			
4	0	6.21	6.530	0.157
5	0	6.50	5.996	0.169
6	0	6.46	6.528	0.161
4	100	6.20	7.730	0.170
5	100	6.27	9.997	0.175
6	100	6.15	7.995	0.164
4	150	6.45	8.130	0.159
5	150	6.38	12.125	0.179
6	150	6.20	11.989	0.170
4	200	5.92	13.722	0.155
5	200	6.28	11.194	0.158
6	200	6.02	13.727	0.161

P=phosphorous and N=nitrogen

Growth performance

The four-year combined analysis of variance showed a significant ($p<0.05$) variation in tree height due to the interaction effect of intra-row spacing and NPS fertilizer rate as indicated in Table 3. The tallest tree (2.66 m) was obtained from a spacing of 6 m and 150 kg/ha NPS fertilizer. However, tree height remained low when untreated with fertilizer regardless of intra-row spacing compared to all the other treatments. Peach height generally increased as the growing season continued. The tallness of peach trees might be due to their wider intra-row spacing combined with optimum fertilization, resulting in low competition for soil nutrients. According to Kidist (2013), increased plant height with NPS application rate illustrated maximum vegetative development due to accumulated NPS availability. The vigor of a tree can also be designated through various growth factors such as photosynthetic rate, biomass, and economic yield (Almeida *et al*. 2016). In addition, the ratio of the canopy's height, thickness, and width needs to be taken into account to guarantee sufficient light levels within the canopy (Corelli and Sansavini, 1989). Taller plants are more productive than shorter trees because they are better at intercepting light (Day *et al*. 1999).

The trunk cross-sectional area (TCSA) of peach trees combined over four years also showed a highly significant ($p<0.01$) difference due to the interaction effects of intra-row spacing and NPS fertilizer rate (Table 3). The highest trunk cross-sectional area of 31.44 cm^2 was exhibited with the intra-row spacing of 6 m and the application of 150 kg/ha NPS fertilizer. Conversely, fertilizer-untreated fruit trees showed the lowest cross-sectional areas irrespective of intra-row spacing. Similarly, Szewczuk and Gudarowska (2012) reported that trunk cross-sectional area depends on the distance between trees in a row. The cross-sectional area of the tree trunk is commonly used to estimate plant size; and fruit production (Jimenez and Diaz, 2004). It is also a reliable predictor of growth and adaptability of tree fruit cultivars in a specific location (Daniel *et al*. 2001). The trunk's enlargement may be caused by the high absorption of the root system, which promotes the growth of organisms to widen the crown, and ultimately the formation of numerous xylem and phloem elements (Kiprijanovski *et al*. 2009). As the growth season progressed, the trunk cross-sectional area often increased regardless of the treatments.

Similarly, branching height was highly significantly ($p<0.01$) affected by the interaction between intra-row spacing and NPS blended fertilizer rate (Table 3) The longest branching height of 59.42 cm was recorded with an intra-row spacing of 5 m, and the application of 150 kg/ha NPS fertilizer. Overall, about 66.7 % of treatments recorded a branching height above the mean. This result might be related to the enhanced hormonal activity in the tree's physiological process due to fertilizer application. The cytokinin hormone translocation between the scion and rootstock impacts branching height, influencing lateral bud growth (Karlidag and Esitken, 2012). Ultimately, tree fruit development is influenced by the height, orientation, and angle of lateral branches with the stem (Yldrm and Kankaya, 2004).

Table 3. Tree height, TCSA, and branching height of the peach tree due to the interaction effect of spacing and NPS fertilizer rate during the 2018-2021 growing seasons

Treatments		Tree height (m)					TCSA (cm^{2})					Branching height (cm)				
Spacing (m) (a)	NPS (kg/ha) (b)	2018	2019	2020	2021	Combined	2018	2019	2020	2021	Combined	2018	2019	2020	2021	combined
4	0	0.76^{g}	1.28^{g}	1.76^{f}	3.34^{e}	1.79^{e}	0.71^{h}	2.30^{e}	9.75^{e}	23.95^{f}	9.18^{f}	22.77^{g}	35.00^{c}	41.00^{e}	59.63^{d}	39.60^{e}
5	0	1.08^{f}	1.63^{e}	2.34^{d}	3.23^{g}	2.07^{d}	1.26^{g}	3.69^{e}	20.13^{cd}	50.68^{bc}	18.94^{cd}	50.77^{c}	49.17^{b}	60.27^{b}	72.27^{a}	58.12^{ab}
6	0	0.80^{g}	1.45^{f}	2.03^{e}	3.15^{h}	1.86^{e}	0.51^{i}	3.09^{e}	11.74^{e}	27.48^{ef}	10.71^{ef}	42.17^{ef}	35.83^{c}	56.67^{bcd}	60.83^{d}	48.87^{d}
4	100	1.23^{e}	2.04^{c}	2.91^{b}	3.28^{f}	2.36^{c}	1.54^{f}	8.57^{cd}	29.45^{b}	52.07^{b}	22.91^{bc}	44.23^{de}	52.23^{ab}	57.77^{bcd}	63.90^{cd}	54.53^{bc}
5	100	1.57^{b}	2.19^{b}	3.15^{a}	3.09^{i}	2.50^{abc}	2.41^{d}	10.58^{bc}	38.18^{a}	58.98^{ab}	27.44^{ab}	39.17^{f}	47.50^{b}	69.33^{a}	69.33^{ab}	56.33^{abc}
6	100	1.24^{de}	2.11^{bc}	2.68^{c}	3.40^{cd}	2.36^{c}	1.77^{e}	6.74^{d}	25.99^{bc}	38.76^{cde}	18.31^{cd}	43.33^{e}	55.83^{a}	62.83^{ab}	73.27^{a}	58.82^{ab}
4	150	1.29^{d}	1.87^{d}	2.66^{c}	3.62^{a}	2.36^{c}	1.59^{ef}	7.61^{d}	22.75^{cd}	34.94^{def}	16.73^{d}	41.43^{ef}	51.67^{ab}	64.13^{ab}	71.10^{a}	57.08^{abc}
5	150	1.38^{c}	2.12^{bc}	2.68^{c}	3.64^{a}	2.45^{bc}	3.19^{b}	11.15^{b}	29.70^{b}	70.77^{a}	28.71^{ab}	58.83^{a}	52.50^{ab}	56.67^{bcd}	69.67^{ab}	59.42^{a}
6	150	1.63^{a}	2.36^{a}	3.23^{a}	3.41^{c}	2.66^{a}	3.25^{b}	14.62^{a}	41.64^{a}	66.24^{a}	31.44^{a}	47.50^{cd}	50.83^{ab}	65.00^{ab}	66.17^{bc}	57.37^{abc}
4	200	1.52^{b}	2.16^{b}	2.87^{b}	3.37^{de}	2.48^{bc}	3.07^{b}	10.59^{b}	29.79^{b}	51.42^{bc}	23.72^{bc}	42.63^{e}	48.33^{b}	59.80^{bc}	62.63^{cd}	53.35^{c}
5	200	1.64^{a}	2.42^{a}	2.90^{b}	3.48^{b}	2.61^{ab}	4.52^{a}	13.52^{a}	30.55^{b}	46.04^{bcd}	23.66^{bc}	55.00^{b}	49.17^{b}	51.50^{cd}	63.77^{cd}	54.86^{bc}
6	200	1.40^{c}	2.16^{b}	2.36^{d}	2.71^{j}	2.16^{d}	2.83^{c}	10.10^{bc}	18.62^{d}	29.70^{ef}	15.31^{de}	39.17^{f}	37.50^{c}	49.33^{de}	60.00^{d}	46.50^{d}
Mean		1.30	1.98	2.63	3.31	2.31	2.22	8.55	25.69	45.92	20.59	43.92	47.13	57.86	66.05	53.74
LSD (0.05)		0.05	0.10	0.17	0.04	0.17	0.20	1.98	5.91	13.25	5.81	3.36	6.26	8.58	4.86	4.35
CV (%)		2.49	2.85	3.87	0.70	8.96	5.26	13.82	13.66	17.12	34.97	4.54	8.88	8.80	4.37	10.01
	a	**	**	**	**	*	**	**	**	**	**	**	*	ns	*	**
Significance	b	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
	a*b	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

Means with the same letter are not significantly different; LSD=least significant different; CV=coefficient of variation; **=significant at 1%; *=significant at 5%; ns=non-significant at 5%; combined= combined mean; and TCSA=trunk cross sectional area

The interaction between intra-row spacing and NPS fertilizer rate had a highly significant ($p<0.01$) influence on the annual shoot growth (Table 4). The longest shoot, measuring 34.13 cm was obtained with an intra-row spacing of 6 m and the application of 0 kg/ha NPS fertilizer. This could be attributed to reduced competition between plants, enabling vigorous growth. Conversely, the shortest shoot growth of 22.57 cm was obtained from an intra-row spacing of 4 m with no fertilizer application (0 kg/ha), possibly due to the highest competition for nutrients. Tree density can influence tree growth through inter-tree competition (Elfving, 1988). Reduced vegetative growth for apples (Christensen, 1979) and peaches (Chalmer *et al*. 1981) has been shown at close spacing.

The canopy volume of peach trees was highly significantly ($p<0.01$) affected by the interaction between intra-row spacing and NPS fertilizer rates as indicated in Table 4. Of the total treatments, 50% of them had more canopy volume than the mean. The highest canopy volume (11.74 m^3) was recorded from a tree with an intra-row spacing of 6 m and 150 kg/ha NPS fertilizer. Generally, canopy volume per given area increased with tree density (Ferree, 1980). Understanding the tree canopy volume is a very important biological parameter that has great significance in predicting the yield of fruit trees and estimating the application rates of pesticides and fertilizers (Zhou *et al*. 2021).

The interaction of intra-row spacing and NPS fertilizer had a significant ($p<0.01$) effect on the canopy stretch of peach trees (Table 4). Amongst, the highest canopy stretch (3.46 m) was obtained from 6 m intra-row spacing and 150 kg/ha NPS fertilizer followed by 5 m intra-row spacing and 150 kg/ha NPS and 5 m and 100 kg/ha NPS with values of 3.08 m and 3.04 m, respectively. Wider spacing with an optimal NPS fertilizer rate of 150 kg/ha resulted in increased lateral growth at the expense of apical growth (Mohammed *et al*. 1984). The wider spacing could also allow the branches to grow wider and result in wider canopy stretch. Excessive fertilizer rates might have aggravated the fixation of available nutrients and changed to unavailable form (Khan *et al*. 2018). Canopy stretch differences can affected by environmental as well as edaphic factors (Nigam, 1992). A reasonable angular opening of the main branches can improve the lighting conditions of the tree body, inhibit the growth of branches, change the direction of nutrient transport, and affect the distribution and balance of endogenous substances (Zhang *et al*. 2023).

Table 4 Annual shoot growth, canopy volume, and canopy stretch of the peach tree due to the interaction effect of spacing and NPS fertilizer rate during the 2018-2021 growing seasons

Treatments		Annual shoot growth (cm)					Canopy volume (m^3)					Canopy stretch (m)				
Spacing (m) (a)	NPS (kg/ha) (b)	2018	2019	2020	2021	Combined	2018	2019	2020	2021	Combined	2018	2019	2020	2021	Combined
4	0	23.00^{g}	14.43^{h}	18.70^{f}	34.13^{bc}	22.57^{g}	0.00^{h}	0.18^{h}	1.77^{i}	10.17^{h}	3.03^{f}	0.10^{j}	0.75^{f}	2.10^{i}	3.62^{g}	1.64^{h}
5	0	33.23^{a}	30.00^{cd}	31.63^{abc}	33.20^{bcd}	32.02^{abc}	0.02^{gh}	0.72^{e}	5.78^{fg}	26.88^{c}	8.35^{bc}	0.28^{h}	1.35^{d}	3.22^{f}	5.96^{b}	2.70^{de}
6	0	32.10^{ab}	34.17^{a}	33.13^{ab}	37.10^{a}	34.13^{a}	0.00^{h}	0.32^{h}	3.10^{h}	13.08^{g}	4.13^{ef}	0.00^{k}	1.02^{e}	2.59^{h}	4.25^{f}	1.96^{g}
4	100	33.87^{a}	33.87^{ab}	33.87^{a}	29.93^{e}	32.88^{ab}	0.01^{h}	1.55^{bc}	9.43^{cd}	24.75^{d}	8.94^{bc}	0.20^{i}	1.82^{b}	3.68^{de}	5.62^{c}	2.83^{b-e}
5	100	28.87^{de}	26.67^{def}	27.77^{cde}	31.73^{de}	28.76^{def}	0.14^{e}	1.09^{e}	11.74^{b}	24.35^{d}	9.33^{abc}	0.62^{ef}	1.52^{c}	4.05^{b}	5.96^{b}	3.04^{bc}
6	100	27.80^{ef}	25.00^{ef}	26.43^{de}	33.67^{bcd}	28.23^{ef}	0.09^{f}	0.53^{g}	6.19^{f}	16.15^{f}	5.74^{de}	0.58^{f}	1.13^{e}	3.12^{f}	4.47^{e}	2.33^{f}
4	150	28.10^{e}	30.57^{bc}	29.37^{bcd}	37.63^{a}	31.42^{bcd}	0.05^{g}	1.03^{e}	8.07^{e}	20.51^{e}	7.41^{cd}	0.40^{g}	1.50^{c}	3.62^{de}	4.95^{d}	2.62^{e}
5	150	29.60^{cde}	18.33^{g}	23.97^{e}	37.10^{a}	27.25^{f}	0.25^{c}	1.38^{d}	8.75^{de}	31.83^{a}	10.55^{ab}	0.85^{c}	1.58^{c}	3.79^{cd}	6.11^{ab}	3.08^{b}
6	150	30.33^{bcd}	28.33^{cde}	29.33^{bcd}	34.27^{b}	30.57^{b-e}	0.39^{b}	2.70^{a}	14.40^{a}	29.46^{b}	11.74^{a}	0.98^{b}	2.24^{a}	4.43^{a}	6.18^{a}	3.46^{a}
4	200	30.83^{bc}	28.33^{cde}	29.60^{a-d}	31.87^{cde}	30.16^{cde}	0.15^{de}	1.69^{b}	10.33^{c}	23.45^{d}	8.90^{bc}	0.65^{e}	1.86^{b}	3.90^{bc}	5.43^{c}	2.96^{bcd}
5	200	31.10^{bc}	35.00^{a}	33.03^{ab}	30.40^{e}	32.38^{abc}	0.50^{a}	1.42^{cd}	8.44^{de}	19.61^{e}	7.49^{cd}	1.10^{a}	1.59^{c}	3.55^{e}	4.94^{d}	2.80^{cde}
6	200	26.23^{f}	23.33^{f}	24.80^{e}	32.20^{b-e}	26.64^{f}	0.18^{d}	1.01^{e}	4.58^{g}	12.42^{g}	4.55^{ef}	0.71^{d}	1.35^{d}	2.88^{g}	4.44^{ef}	2.34^{f}
Mean		29.82	27.34	28.47	33.60	29.75	0.15	1.14	7.72	21.06	7.51	0.54	1.48	3.41	5.16	2.65
Lsd (0.05)		1.83	3.36	4.41	2.28	2.70	0.03	0.17	1.29	1.72	2.41	0.04	0.11	0.18	0.21	0.26
Cv (%)		3.66	7.29	9.19	4.03	11.24	13.67	9.08	9.92	4.84	39.74	4.71	4.33	3.17	2.38	12.38
Significance	a	**	ns	ns	ns	ns	**	ns	**	**	*	**	*	**	**	**
	b	ns	*	ns	**	ns	**	**	**	**	**	**	**	**	**	**
	a*b	**	**	**	*	**	**	**	**	**	**	**	**	**	**	**

Means with the same letter are not significantly different; LSD=least significant difference; CV=coefficient of variation; **=significant at 1%; *=significant at 5%; and ns=non-significant at 5%.

Conclusion

Most of the main growth performance parameters, such as plant height, trunk cross-sectional area, canopy volume, and canopy stretch, showed better performance due to the interaction between intra-row spacing and NPS fertilizer rate. The growth performance was highest with 6 m intra-row spacing and an NPS fertilizer rate of 150 kg/ha. Conversely, intra-row spacing of 5 m with 150 kg/ha NPS fertilizer and intra-row spacing of 6 m without NPS fertilizer demonstrated superior branching height and annual shoot growth performance, respectively. Hence, higher growth performance of peach trees could be achieved by using 6 m intra-row spacing with 150kg/ha blended NPS fertilizer rate and this will eventually correspond to higher tree productivity.

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Contribution of authors

The authors contributed significantly to the article's concept or design, data collection, analysis, and interpretation of the results, drafting the article and revising the necessary intellectual content, and approving the document for publication, even if the corresponding author contributed more. We have also promised to be accountable for all parts of the work, including ensuring that any concerns about the accuracy or integrity of any portion of the work are properly investigated and handled. The authors also declare that there is no conflict of interest.

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