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Summer pruning and branch bending of peach trees in a subtropical region

Abstract – The objective of this work was to quantify peach (*Prunus persica*) tree production in the Y-training and open-vase management systems, subjected to three summer pruning methods. The experiment was set up in a 2x3 factorial arrangement, with two management systems and three summer pruning methods (no summer pruning, summer pruning, and branch bending). The plants were arranged in two spacings: 1.5x5.0 m for the Y-training system, with 1,334 plants per hectare; and 4.0x5.0 m for open-vase system, with 500 plants per hectare. In the early summer of 2019, summer pruning was performed, being repeated in the three following years. In the branch bending treatment, new branches were twisted manually until reaching an angle of 110°. In the treatment without summer pruning, the branches were not removed. The Y-training system increases peach production. The methods of branch bending in summer and no prunning in summer provide an equivalent peach production, whereas the summer pruning treatment results in the lowest production.

Index terms: *Prunus persica*, defoliation, spacings.

Poda de verão e dobramento de galhos de pessegueiros em região subtropical

Resumo – O objetivo deste trabalho foi quantificar a produção de frutos de pessegueiros (*Prunus persica*) sob os sistemas de manejo Y e vaso aberto, sujeitos a três métodos de poda de verão. O experimento foi instalado em arranjo fatorial 2x3, com dois sistemas de manejo e três métodos de poda de verão (sem poda de verão, poda de verão e dobramento de galhos). As plantas foram dispostas em dois espaçamentos: 1,5x5,0 m para o sistema Y, com 1.334 plantas por hectare; e 4,0x5,0 m para o sistema vaso aberto, com 500 plantas por hectare. No início do verão de 2019, foram realizadas as podas de verão, que foram repetidas nos três anos consecutivos. No tratamento dobramento de galhos, os ramos novos foram torcidos manualmente até atingirem o ângulo de 110º. Já no tratamento sem poda de verão, os ramos não foram retirados. O sistema Y aumenta a produção de pêssego. Os tratamentos dobramento de galhos no verão e sem poda de verão proporcionam equivalente produção de pêssego, enquanto o tratamento poda de verão resulta na menor produção.

Termos para indexação: *Prunus persica*, desfolha, espaçamentos.

Lucidio Henriques Vote Fazenda[(1)], Pedro Maranha Peche[(1)], Alexandre Dias da Silva[(1)], Jucimar Moreira de Oliveira[(1)], Fabiano Luis de Sousa Ramos Filho[(1)] and Rafael Pio[(1 ✉)]

[(1)] Universidade Federal de Lavras, Escola de Ciências Agrárias de Lavras, Campus Universitário, Trevo Rotatório Professor Edmir Sá Santos, CEP 37203-202 Lavras, MG, Brazil.
E-mail: lucidiofazenda@gmail.com, pedro.peche@ufla.br, alexandre.silva7@estudante.ufla.br, jucimar.oliveira@estudante.ufla.br, fabiano.filho@estudante.ufla.br, rafaelpio@ufla.br

✉ Corresponding author

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Introduction

In recent years, temperate fruit crops in subtropical regions have increased rapidly (Tadeu et al., 2019b), which includes the exploitation of peach trees (*Prunus persica* L.) that has expanded especially in

Brazil, due to the development of cultivars with lower chilling requirements (Souza et al., 2013; Pio et al., 2019).

Peach cultivars adapted to the subtropical climate have lower chilling requirements, ranging from 70 to 200 hours at temperatures below 7.2°C, during the endodormancy period of the buds (Souza et al., 2017). Therefore, mild winter climatic conditions in subtropical regions correspond to the temperatures of the dormancy period of the plants (Scariotto et al., 2013). Citadin et al. (2014, 2022) observed that temperatures of approximately 12°C are believed to be effective to overcome endodormancy in cultivars adapted to the subtropical climate.

Commercial orchards use open-vase training system, which corresponds to low planting densities and open management systems with four main branches. However, open-vase training system is better for peach trees in temperate regions because it allows good insolation of the crown and fruits (Uberti et al., 2020).

In subtropical regions, it is indicated to use the Y-training system, in which plants are trained with only two main branches (Souza et al., 2019a). Despite being less common, these orchards have higher planting densities and modern management systems (Viol et al., 2021). Essentially, this system is used to increase productivity, maximize crop treatments, and protect the main axis of plants against the sun (Souza et al., 2019b).

Additionaly, summer pruning, performed between late spring and early summer, is an alternative to maximizing peach tree production in subtropical regions. The technique consists of removing branches after harvesting the fruits, leaving only the trunk and secondary branches, so that, approximately 30 days after pruning, the plant resprouts, initiating vegetative growth and then floral differentiation of the buds for the next cycle (Araújo et al., 2008).

In apple orchards, branch bending has been a common practice. This method consists of dry bending, this is, manually twisting the productive branches during the dormancy period to the point of reaching an angle from 70° to 110° in inclination in relation to the main axis to increase the formation of flower buds (Zhang et al., 2017). Zhang et al. (2023) also used this practice in peach trees at the time of dry pruning in the autumn and winter pruning to allow more light into the canopy of the plant, stimulating the formation of flower buds and improving fruit quality.

In subtropical regions, instead of performing branch bending during the summer, it is more indicated during dormancy, after the peach harvest, to improve the formation of flower buds and minimize problems with summer diseases, such as leaf rust [*Tranzschelia discolor* (Fuckel) Tranzschel & Litvinov], especially in high-density orchards.

The objective of this work was to quantify peach fruit tree production in the Y-training and open-vase management systems, subjected to three summer pruning methods.

Materials and Methods

The experiment was conducted in the municipality of Lavras, in the state of Minas Gerais, Brazil (21°14'S, 45°00'W, at 918 m of altitude). According to the Köppen-Geiger climate classification, the local climate is Cwb, tropical high altitude (mesothermic), with dry winters and rainy seasons between October and March, with greater intensity between December and February (Alvares et al., 2013).

According to the Brazilian Soil Classification System (Santos et al., 2018), the soil at the study site is classified as Cambissolo Háplico or Haplic Cambisol (Guimarães et al., 2021). The soil analysis in the 0–20 cm depth layer revealed the following attribute values: 5.7 pH, 47.5 g dm^{-3} organic matter, 152.3 mg dm^{-3} phosphorus (Mehlich-1 extractor), 10.1 mmol$_c$ dm^{-3} calcium, 2.3 mmol$_c$ dm^{-3} magnesium, 13.2 mmol$_c$ dm^{-3} bases sum, and 16.2 mmol$_c$ dm^{-3} cation exchange capacity.

To prepare the experimental area, the following composts were applied: 2.5 Mg ha^{-1} dolomitic limestone broadcast on soil surface; and 10 L organic matter added to mineral fertilizer sources of phosphorus (400 g simple superphosphate) and potassium (200 g potassium chloride) per seedling planting hole for base fertilization.

The experimental area was prepared in October, and the grafted seedlings were planted in November 2016. One-year-old seedlings of 'BRS Rubimel' were grafted on 'Okinawa' rootstock. The seedlings were arranged in two different spacings, in accordance with the following management system: for Y-training, with a tree density of 1,334 plants per hectare, it was 1.5 m between trees in rows x 5.0 m between rows; and for open-vase training system, with a tree density of 500 trees per hectare, it was 4.0 m between trees in rows x 5.0 m between rows.

In the Y-training system, between planting rows, two opposite shoots were selected; whereas in the open-vase training system, four shoots, 90º angle equidistant from the central axis, were selected. To form the crown structure, the selected shoots were bent at a 60° angle from the central axis. The branches were tied with plastic tape to the wooden stakes fixed in the soil for eight months, period in which the branches reached sufficient maturation and lignification to remain at the desired angle.

The experiment was carried out in randomized complete block design, in a 2x3 factorial design, with the first factor being the two management systems, Y-training and open-vase, and the second factor being three branch management methods: no summer pruning, summer pruning, and branch bending, with four blocks, containing five plants, and the three central ones being the useful plot per experimental unit.

In all years after planting, at the end of the autumn, first week of June, dry pruning was performed on all plants of the experiment, when the plant buds were still dormant. Dormex hydrogen cyanamide (BASF, Indaiatuba, SP, Brazil) at a concentration of 0.25% a.i. was used immediately after the dry pruning operation to standardize flowering and budburst.

In the early summer of 2019, last week of December, pruning was performed, which was repeated in the next three consecutive years. In the treatment that received branch bending, the produced branches were twisted manually until reaching a 110° angle according to the methodology by Zhang et al. (2017). In the no summer pruning treatment, the branches were not removed. Data collection began during the 2020 dry pruning.

In the two production cycles of 2020 and 2021, the percentages of flowering and budbreak were evaluated by marking four 15-centimter branches per useful plant after dry pruning, and by counting the number of flowering and vegetative buds. Fifteen days after full flowering and budding, the number of flowering and sprouting buds was counted, and the percentages were calculated.

The average number of fruits per plant, average production in kg per plant, and estimated average yield in Mg ha^{-1} in the two production cycles were evaluated from October to November. The fruits collected at each weekly harvest were counted and weighed using a SHI-AUX-220 semianalytical digital scale (Shimadzu, Barueri, SP, Brazil). At the end of the production cycle, all the recorded masses were added together to determine the production per plant, and, subsequently, the estimated yield was calculated by multiplying production by population density, which was of 1,334 plants per hectare for Y-training system, and of 500 plants per hectare for open-vase system.

The longitudinal and transverse diameters of the fruit were obtained using a digital caliper. Measurements were conducted on ten fruits randomly collected from each experimental plot, with two measurements per fruit of the longitudinal and transverse faces to obtain the average in centimeters. To determine the average fruit mass in grams, ten fruits per experimental plot were weighed with the aid of a SHI-AUX-220 semianalytical digital scale. Soluble solids were determined by a RTD-45 digital refractometer (Cial, São Paulo, SP, Brazil), using 20 fruits per experimental plot, at an average temperature of 20°C. A homogenizing agent was added to the samples by using 1 to 2 drops of raw material spray, and the results were expressed in °Brix.

After summer pruning in 2021, fungicide spraying was suspended to evaluate the incidence of leaf rust, considering its presence or absence. The first 30 cm of four branches per plant were marked, and the total number of leaves per branch was quantified. The number of leaves with rust and the incidence percentage were calculated, according to the methodology by Rodrigues et al. (2008), 47, 61, and 75 days after the pruning method (no summer pruning, summer pruning, and branch bending) was conducted.

After summer pruning in 2022, fungicide spraying was suspended to evaluate the percentage of defoliation, which was determined by marking six growth shoots of approximately 30 cm in length per experimental plot. Defoliation was determined for each sampling date and expressed as a percentage. The percentage of defoliation was determined by counting the total number of leaves on day zero, which was the day summer pruning was carried out, and after 40, 47, and 54 days. The percentage of defoliation was determined by the following formula: defoliation = 100 - (NLE/INL × 100), where NLE is

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the number of leaves on the evaluation date and INL is the initial number of leaves after summer pruning.

The data were subjected to the Tukey comparison of means test, at 5% error probability. The analyses were performed using the Sisvar Analysis of Variance Computer Program, version 5.6 (Ferreira, 2019).

Results and Discussion

Regarding the management systems used for the peach trees, the statistical analysis revealed that there was no significant difference in the percentages of budbreak, flowering, average fruit weight (Table 1), and fruit quality (Table 2). Therefore, there was no interaction between the management systems and summer pruning in all evaluated traits, and there was no interaction between the seasons.

However, in both evaluated cycles, the results showed that fruit production per plant is higher in the open-vase system than in Y-training system (Table 1), due to the greater number of main branches. In the open-vase system, the plants are trained with four equidistant branches at an angle close to 90°, and in the Y-training system, with two equidistant branches at an angle close to 180°. Uberti et al. (2020) also observed that the production of peaches, in kg per plant, is lower in the Y-training system than in the open-vase system.

Regarding the estimated yield, plants grown in the Y-training system had a higher estimated yield compared to plants grown in the open-vase system (Table 1), which was the opposite found for fruit

Table 1. Percentage of budbreak and flowering, average fruit weight, average number of fruits, production, and estimated yield of 'BRS Rubimel' peach tree (*Prunus persica*) in Y-training and open-vase systems, subjected to three pruning treatments in the summer: no summer pruning (NP), summer pruning (SP), and branch bending (BB) in the 2020 and 2021 production cycles, in the municipality of Lavras, in the state of Minas Gerais, Brazil(1).

Training system	Budbreak (%)		Flowering (%)		Average fruit weight (g)		Number of fruits		Production (kg per plant)		Estimated yield (Mg ha^{-1})(2)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
Y-training	82.3a	83.2a	81.4a	82.5a	61.6a	62.9a	130.2b	170.6b	8.0b	10.5b	10.7a	14.1a
Open vase	84.3a	83.9a	81.1a	86.4a	60.5a	60.5a	165.9a	203.2a	10.0a	12.1a	5.0b	6.0b
Summer treatment												
NP	83.7a	83.8a	83.5a	83.7a	60.8a	62.7a	170.4a	222.4a	10.4a	13.5a	9.0a	12.0a
SP	75.7b	76.0b	69.9b	79.2b	61.2a	61.5a	79.4b	91.3b	4.8b	5.5b	4.1b	4.7b
BB	90.5a	90.8a	90.5a	90.5a	61.1a	60.9a	194.5a	247.0a	11.9a	15.0a	10.5a	13.5a
CV (%)	15.0	14.8	12.7	14.6	9.3	9.6	12.3	14.2	13.9	15.4	13.9	15.4

(1)Means followed by equal letters, in the rows, do not differ from each other by Tukey's test, at 5% probability. (2)Calculation considering a spacing of 1.5 m x 5 m in the Y-training system (density 1,334 plants per hectare) and 4 m x 5 m in the open-vase system (density 500 plants per hectare).

Table 2. Average fruit length, average fruit diameter, and total soluble solids of fruits of 'BRS Rubimel' peach tree (*Prunus persica*) in Y-training and open-vase systems, subjected to three pruning treatments in the summer: no summer pruning (NP), summer pruning (SP), and branch bending (BB) in the 2020 and 2021 production cycles, in the municipality of Lavras, in the state of Minas Gerais, Brazil(1).

Training system	Average fruit length (mm)		Average fruit diameter (mm)		Total soluble solids (°Brix)	
	2020	2021	2020	2021	2020	2021
Y-training	61.6a	60.2a	51.3a	51.0a	9.5a	9.8a
Open vase	61.0a	62.6a	53.1a	55.1a	9.8a	9.8a
Summer treatment						
No summer prunning (NP)	61.9a	63.7a	52.7a	52.7a	9.7a	9.8a
Summer prunning (SP)	61.0a	59.7a	53.1a	55.8a	9.8a	9.5a
Branch bending (BB)	61.2a	61.0a	51.0a	50.7a	9.6a	9.9a
CV (%)	7.2	7.1	8.1	9.6	10.6	11.9

(1)Means followed by equal letters, in the rows, do not differ from each other by Tukey's test, at 5% probability.

production per plant. This difference is due to the greater number of peach trees arranged in the same area, since the population density in the Y-training system was higher: 1,334 plants per hectare, whereas in the open-vase system it was 500 plants per hectare.

According to Pasa et al. (2017), the quality of peaches produced does not change significantly when comparing low- and high-density planting systems. However, Bussi et al. (2015) found higher productivity of peaches at a high planting density.

The different summer management practices did not promote differences in the quality of the peaches (Tables 1 and 2), corroborating Uberti et al. (2020), who found that phenological development and fruit quality are not affected by management systems.

However, the percentage of budbreak and flowering was higher in experiment with no summer pruning and in the branch bending treatments compared with the summer pruning treatment (Table 1). According to Borba et al. (2005), there is a decline in root carbohydrates in peach trees shortly after summer pruning. According to the authors, summer pruning stimulates the production of new shoots that consume part of the root reserves. This explains the higher percentage of budbreak and flowering after dry pruning in plants that had not previously received summer pruning and those that had received summer branch bending.

In summer branch bending, instead of removing the branches, they are twisted, so the leaves continue to accumulate reserves, which demonstrates that keeping the leaves after peach harvest is fundamental for the plant to continue performing photosynthesis and accumulating reserves to be used in the following cycles. According to Zhang et al. (2023), branch bending promotes the best use of light on the plant canopy and, consequently, the formation of flower buds.

Regarding productive performance, this is, number of fruits measured by the average number of fruits and production in kg, plants subjected to branch bending and without summer pruning were more productive compared with plants subjected to summer pruning (Table 1). According to Araújo et al. (2008), summer pruning promoted a decrease in peach production compared with peach trees that did not receive summer pruning.

There was no significant difference in the incidence of leaf rust, which confirms the findings of Rodrigues et al. (2008) and merited the evaluation of defoliation in the following year.

However, when evaluating the percentage of defoliation, there was a difference between the summer pruning methods at 54 days after harvest (Figure 1). Plants that did not receive summer pruning showed the highest defoliation rate (90%), while those that received summer pruning had the lowest defoliation rate (71%). The results corroborated Araújo et al. (2008), who emphasized that, after harvesting the fruits, rust can cause early defoliation, leading to a reduction in vigor or productivity in the next production cycle. The summer branch bending treatment showed a lower tendency of defoliation compared with the no summer pruning method.

The main benefit of summer pruning is to delay leaf fall, which prevents peach trees from flowering and budding in the early autumn in subtropical regions (Araújo et al., 2008). Leaves perform vital functions in plants because photosynthesis occurs in these plant organs. Furthermore, Tadeu et al. (2019a) highlighted the contribution of leaves in the process of floral induction as well as in the production of substances that stimulate flowering.

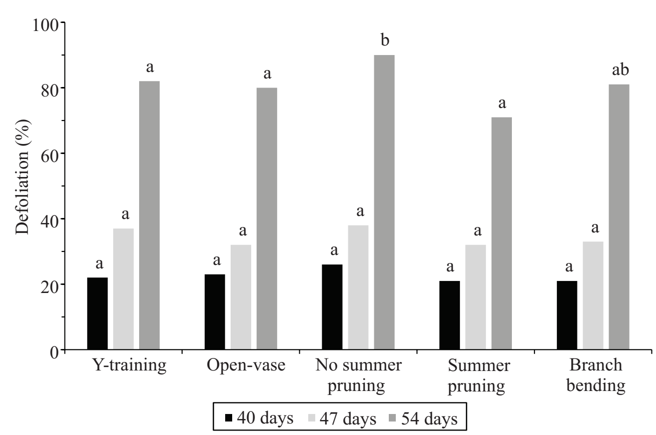

Figure 1. Defoliation rates of 'BRS Rubimel' peach tree (*Prunus persica*) branches in Y-training and open-vase systems, subjected to three summer prunings: no summer pruning, summer pruning, and branch bending, at 40, 47 and 54 days after pruning, in the 2022 production cycle, in the municipality of Lavras, in the state of Minas Gerais, Brazil. Means followed by equal letters, in the columnsrows, do not differ from each other by Tukey's test, at 5% probability.

It was observed that there were large differences among treatments at 54 days: the greater the leaf drop, the lower the production per plant. Baldissera & Petri (2020) highlighted the importance of retaining leaves in the period after peach harvest for them to accumulate carbohydrate reserves.

Conclusions

1. The Y-training system increases peach (*Prunus persica*) fruit production.
2. Branch bending method carried out in the summer and no summer pruning method provide equivalent peach fruit production, and summer pruning method results in the lowest peach production.

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