ISSN 0100-2945
DOI: http://dx.doi.org /10.1590/0100-29452019122
Revista Brasileira de Fruticultura
Crop production

The effect of planting density on 'BRS Rubimel' peach trained as a "Y-shaped" system

André Luiz Kulkamp de Souza[1], Edson Luiz de Souza[2], Samila Silva Camargo[3], Nelson Pires Feldberg[4], Mateus da Silveira Pasa[5], Angélica Bender[6]

Abstract-The densification of orchards has become a viable alternative for producers seeking a greater use of current area, as well as greater profitability. In this sense, the spacing and training system to be used in the peach tree planting are extremely important to facilitate orchard management and, above all, to maximize tree yield. Based on this, the present research aimed to evaluate the possibility of orchard densification and the use of different numbers of main scaffolds to recommend the best way of training and spacing the 'BRS Rubimel' peach cultivar. The planting was carried out in 2010, in the city of Fraiburgo - SC, and eight treatments with different spacings between the plants in the rows and number of scaffolds were evaluated during four harvests (2013, 2014, 2015 and 2016): T1- 2 scaffolds and 0.75 m; T2- 2 scaffolds and 1.00 m; T3- 2 scaffolds and 1.25 m; T4- 2 scaffolds and 1.50 m; T5- 4 scaffolds and 1.00 m; T6- 4 scaffolds and 1.50 m; T7- 4 scaffolds and 1.75 m; T8- 4 scaffolds and 2.00 m, totaling a plant density of 2667, 2000, 1600, 1333, 2000, 1333, 1143 and 1000 per hectare, respectively. The analyzed variables were the number of fruits per plant, production per plant (kg); productivity (t ha-1); fresh fruit mass (g), total soluble solids content (ºBrix), total acidity (meq L^{-1}), epidermal coloring and pulp firmness (pounds). The highest yields were found in the treatment with two scaffolds and 0.75m between plants, as well as that with 4 scaffolds in 1.0 m spacing in the 2014 and 2015 crops and two scaffolds in 1.0m in the 2015 harvest. The fresh mass, soluble solids, total acidity and fruit firmness were not influenced by the different treatments. It was concluded that the densification of orchards is feasible for peach trees of the 'BRS Rubimel' cultivar due to the increase in productivity, without decreasing the quality of the fruits, indicating a spacing of 0.75 cm between plants and two scaffolds in the "Y-shape" as ideal. Another option with good results is the use of the four-scaffold "Y-shaped" training system, indicated for the 'BRS Rubimel' peach trees, due to the maintenance of high yields and reduction in the number of plants per hectare when compared to treatments with two scaffolds.
Index Terms: *Prunus persica* (L.) Batsch; tree training; spacing; planting density.

Resposta do adensamento de plantio de pessegueiros 'BRS Rubimel' conduzidos no sistema de "Y"

Resumo-O adensamento de pomares tem se tornado uma alternativa viável na busca de maior aproveitamento da área e rentabilidade. Nesse sentido, o espaçamento e o sistema de condução a ser utilizado no plantio de pessegueiro são extremamente importantes para facilitar o manejo do pomar e sobretudo, maximizar a produtividade do pomar. Com base nisso, buscou-se avaliar a possibilidade de adensamento de pomares e o uso de diferentes números de pernadas principais a fim de recomendar a melhor forma de condução e espaçamento de plantio do pessegueiro cultivar BRS Rubimel. O plantio foi realizado no ano de 2010, na cidade de Fraiburgo – SC e oito tratamentos com diferentes espaçamentos entre as plantas nas linhas e número de pernadas foram avaliados durante quatro safras (2013, 2014, 2015 e 2016): T1- 2 pernadas e 0,75 m; T2- 2 pernadas e 1,00 m; T3- 2 pernadas e 1,25 m; T4- 2 pernadas e 1,50 m; T5- 4 pernadas e 1,00 m; T6- 4 pernadas e 1,50 m; T7- 4 pernadas e 1,75 m; T8- 4 pernadas e 2,00 m, totalizando uma densidade de plantas de 2.667, 2.000, 1.600, 1.333, 2.000, 1.333, 1.143 e 1.000 por hectare, respectivamente. As variáveis analisadas foram o número de frutos por planta, produção por planta; produtividade; massa fresca dos frutos, teor de sólidos solúveis totais, acidez total, coloração de epiderme e firmeza de polpa. Concluiu-se que o adensamento de pomares é viável para pessegueiros do cultivar BRS Rubimel devido ao aumento da produtividade, sem decréscimo da qualidade dos frutos, sendo indicado espaçamento de 0,75 cm entre plantas e duas pernadas no "Y". Outra opção com bons resultados é o uso do sistema de condução com quatro pernadas, indicada por proporcionar a manutenção de altas produtividades e a redução no número de plantas por hectare em relação aos tratamentos com duas pernadas.
Termos para indexação: *Prunus persica* (L.) Batsch; condução; espaçamento; densidade de plantio.

Corresponding author:
andresouza@epagri.sc.gov.br

Received: October 02, 2018
Accepted: December 10, 2018

[1]Dr. Pesquisador, Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina, Videira-SC, Brasil. E-mail: andresouza@epagri.sc.gov.br (ORCID 0000-0003-4889-6291)

[2]Dr.Professor, Universidade do Oeste de Santa Catarina (UNOESC), Videira, Santa Catarina, Brasil. E-mail: edsonluizdesouza@gmail.com (ORCID 0000-0001-8238-1529)
[3]Dra. Prof., Serviço Nacional de Aprendizagem Industrial (SENAI), Videira-SC, Brasil. E-mail: samilasc@yahoo.com.br (ORCID 0000-0002-0659-1361)
[4]Me., Analista, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Canoinhas, Santa Catarina, Brasil. E-mail: nelson.feldberg@embrapa.br
[5]Dr., Professor, Oregon State University (OSU), Hood River, Oregon, EUA. E-mail: mateus.pasa@oregonstate.edu (ORCID 0000-0003-0481-0206)
[6]Enóloga, Doutoranda, Universidade Federal de Pelotas, Pelotas, RS, Brasil. E-mail: bender.angelica.fruti@gmail.com (ORCID 0000-0002-1141-6090)

Introduction

Peach is one of the world's most popular fruits with a considerable consumption, mainly due to a flavor that meets the different consumer demands (CHENG et al., 2015). The cultivation of the peach tree is already consolidated in the South of Brazil; however, the detailing of production techniques is still necessary due to the different plant responses when submitted to different growing conditions (CARVALHO et al., 2015).

The definition of planting spacing and the training system to be used in a peach orchard should take into account the production capacity and access of solar radiation by the fruits, which result in greater color intensity, ease in phytosanitary treatments and rationalization of the workforce, especially in cultivation handling and harvesting. The manipulation of the plant architecture in new configurations, when integrated to the specific planting systems can be an alternative to increase the productivity and efficiency of the orchards (Tustin, 2014).

Several authors point out the advantages of high-density peach tree plantations, such as the higher productivity of manual labor due to the maintenance of more compact trees, increased productivity per area and productive efficiency and, consequently, economic return (TOMAZ et al., 2010; MAYER; PEREIRA, 2012; HOZA et al., 2015; MAYER et al., 2016). Once a trend, the increase in planting density has become a reality in Brazilian and global fruit growing, but in the peach crop cultivation, the planting densities face difficulties mainly due to the high vegetative growth caused by the use of vigorous rootstocks produced by seeds. For these cropping systems, it is necessary to reduce vigor through a more compact tree training (SOUZA et al., 2017), which require specific management in order to achieve efficient light penetration in the trees canopy (HOZA et al., 2015). where any reduction of photosynthesis results in poor growth, delayed or insufficient flowering, and consequently lower yield (FERREIRA et al., 2018). Studies of the influence of the number of structural branches and production, from the substitution of two to four branches are sought aiming at reducing plant vigor, as well as a better balance between vegetation and production.

In order to evaluate the possibility of orchard densification and to recommend the best Y-shaped training and planting spacing of 'BRS Rubimel' peach cultivar, the objective of this study was to evaluate the effect of different numbers of major scaffolds and spacings between plants on productive characteristics and fruit quality.

Material and Methods

The study was carried out in the municipality of Fraiburgo (Latitude 27º 01'05.9" S; Longitude 51º 00' 58" W; Altitude: 1,038 m) in 'BRS Rubimel' peach orchard. According to the Koppen classification, the climate of the region is classified as Cfb - mesothermal moist and mild summer (ALVARES et al., 2013). The climatic data of the region where the research was carried out are presented in Table 1, with the characterization of the relative air humidity (%), average, maximum and minimum temperatures (ºC), average precipitation (mm), accumulated cold hours (below 7.2ºC) in the years 2013 to 2016 (EPAGRI/CIRAM, 2018).

Planting was carried out in 2010 following a block randomization experimental design, with five replications of five plants where the three internal plants of each plot were evaluated to isolate the border effect. The rootstock was 'Capdeboscq' and the seedlings were planted in spacing between 5.0 m rows and trained in the 'Y-shaped' system. The treatments tested were the number of main plant scaffolds and the spacing of the planting: T1- 2 scaffolds and 0.75 m; T2- 2 scaffolds and 1.00 m; T3- 2 scaffolds and 1.25 m; T4- 2 scaffolds and 1.50 m; T5- 4 scaffolds and 1.00 m; T6- 4 scaffolds and 1.50 m; T7- 4 scaffolds and 1.75 m; T8- 4 scaffolds and 2.00 m, totaling a plant density of 2,667, 2,000, 1,600, 1,333, 2,000, 1,333, 1,143 and 1,000 per hectare, respectively. The fertilization was based on the Manual of Fertilization and Liming for the States of Rio Grande do Sul and Santa Catarina and the management of the plants followed that recommended for the culture.

The evaluations were carried out in 2013, 2014, 2015 and 2016, totaling four complete harvests. The fruits of the observed plants were harvested, weighed and taken to the laboratory of the Epagri Experimental Station in Videira/SC to analyze the number of fruits per plant, production per plant (kg); estimated productivity (t ha^{-1}); fresh fruit mass (FFM - g), total soluble solids (TSS - ºBrix), total acidity (TA - meq $L^{-}1$), epidermal coloring (color scale) and pulp firmness (PF - Pounds).

The average production per plant was performed by weighing the harvested fruits per plot, divided by the number of plants. Based on the planting density of each treatment, productivity was estimated. The fresh fruit mass was evaluated in a precision scale, by weighing all harvested fruits. After weighing and counting, a sample of 20 fruits per replicate was randomly picked to obtain the other parameters. Soluble solids content was determined through a digital refractometer; the total acidity by titration, using 10 mL of juice, diluted in 90 mL of distilled water and titrated with 0.1 N sodium hydroxide to pH 8.1; the pulp firmness by means of a manual penetrometer; and the fruit coloring was determined by a color scale ranging from 1 to 4, being > 80% red, 60-80% red, 40-60% red, and 20-40% red, respectively.

The data were submitted to the Shapiro-Wilk normality test. The fruit coloring variable, from the 1 to 4 color scale were transformed through the expression [log (x + K)], where x is the mean obtained from each variable and K is equal to 1. Analysis of variance was carried out and when significant, the means of the treatments were compared by the Tukey test, at a level of 5% error probability.

Results and discussion

The number of fruits per plant is shown in Table 2, where it is verified that an interaction occurred between the spacings and number of scaffolds with the analyzed harvests. The results indicate that the treatments which stood out were: four scaffolds and 2.0 m in the 2015 and 2016 crops; and four scaffolds and 1.75 m in the 2016 crop. The lower the number of plants per hectare, the higher the number of fruits per plant, this is due to the greater size of the plants when cultivated in less dense plantations. In studies with the same species, Mayer et al. (2016) also found that the number of fruits affected the production per plant, with differences based on the different crops and planting spacing. The number and mass of fruits depend on the fruit load in the plants, but a relationship between higher yield and smaller fruit size, and vice versa is not always observed (ALMEIDA et al., 2014), further having the influence of the different harvests studied.

When analyzing the production per 'BRS Rubimel' peach tree, a similar reasoning was obtained for the number of fruits, where it was shown that in the years 2015 and 2016, the orchard trained in a less dense manner and with a greater number of scaffolds (T7 and T8) produced more fruits per plant, with an average of 27 kg (Table 3). The treatments that produced the most fruits were the plants that had four main branches and, thus, a larger number of productive branches. The highest number of fruits and yield per plant occurred in the treatments in which the plants were larger, since they occupy the space between one and the other, that is, the less densely packed the orchard, the larger the plants and the greater the number of plants, and consequently the higher the number of fruits produced. However, when it comes to the densification of orchards, we think of increased production per area, despite the lower production per plant, since we have a greater number of plants per hectare. Pramanick et al. (2012) emphasize that one of the most pertinent criteria in the densification is the maximization of yield of the orchard area, making it possible to use a greater number of plants per hectare. However, this condition should not jeopardize the physiological aspects of the crop. The planting densification does not reduce the size of the fruits, but can significantly increase productivity (MAYER et al., 2016) and this yield can be verified from the first year of production of the peach tree orchards.

The treatments with four scaffolds become interesting for allowing high productivity as well as a lower cost of implantation of the orchard since the number of scaffolds is doubled compared to the traditional "Y". It is possible to obtain a higher production per plant even with high planting density, with a better balance between vegetation and production, acting in control of vigor and consequently, less need for green pruning.

The highest yields were found in the treatment with two scaffolds and 0.75m between plants (Table 3), with no significant differences from the 4-scaffolds ones in 1.0 m spacing in the 2014 and 2015 crops, and two scaffolds in the 1.0m in the 2015 crop. When considering the sum of the four harvests, we can see that the treatment with two scaffolds and 0.75 m obtained greater productivity in relation to the other spacings, which shows that the planting densification provides greater productivity in the 'BRS Rubimel' peach trees. Similar research with 'Aurora-1' peach trees showed advantageous results with reduced plant spacing, which led to increases in fruit size, productivity and even a reduction in the harmful effects of the sun on the scaffolds of plants (MAYER; PEREIRA, 2012; MAYER et al. 2014).

Still evaluating the sum of the productivities, in the first four years of production, the difference between the plants with 0.75 and 1.5 m of spacing with two scaffolds each stands out, which was approximately 63 tons per hectare. When comparing the two factors studied, significant results were also obtained, where plants with 2 scaffolds and 1.50 m spacing produced around 17 tons less than the T6 treatment, with 4 scaffolds and the same distance between plants.

The current planting system of the Vale do Rio Peixe with two scaffolds and planting between 1.25m (T3 - 30.7 t ha^{-1}) and 1.50m (T4 - 26.4 t ha^{-1}) are among the lowest productivities when compared to the most productive (T1 - 49.2 t ha^{-1}), thus, produce about 20 tons less per year, a quantity that is of utmost importance in the final production of the orchard. The higher value spent on the acquisition of seedlings in the more densified system is compensated with higher yields, and the difference in value of the seedlings can be paid as early as the first harvest with the highest productivity. These results meet the main objectives sought by the producers, where according to Maas (2008), Gleen et al. (2011) and Pasa et al. (2017), the quickest return on investment with high yields, can be achieved by increasing planting density in these more modern cropping systems.

Peach trees trained with four scaffolds provide, in addition to the production characteristics, more balanced plants and consequently require less interference of green pruning per hectare, which reduce labor costs, as well as the initial cost of seedlings, since each plant occupies the space of two. Another highlight of this training system with a greater number of scaffolds is related to the physiological part of the plants, where with double scaffolds, the intrinsic vigor (from the combination of rootstock and crown and edaphoclimatic conditions favorable to vegetative growth) is distributed in a greater number of branches, which results in a greater balance of the plant. This strategy of using rootstocks that induce less vigor in densified orchards is already widely used in apple tree crops and shows that it can also be used in other crops such as the peach tree (GALARÇA et al., 2013).

The fresh mass, soluble solids, total acidity and pulp firmness of 'BRS Rubimel' fruits were not influenced by the different treatments studied (number of scaffolds and spacing), in contrast, significant differences were presented ($p < 0.05$) in the four harvests analyzed (Table 4). These results show that regardless of the spacing or number of scaffolds, the fruits kept the size and, in addition, the soluble solids content were not affected by the greater densification and number of leaders per plant. Corroborating with this information, in studies with 'Chimarrita' peaches, Mayer et al. (2016) also concluded that the high-density planting did not affect the productive potential of the plants and, consequently, the physical characteristics of the fruits, such as mass and diameter.

The first year of evaluation (2013) resulted in fruits with the highest values of fresh mass (130.51 g), soluble solids content (10.95 ºBrix) and pulp firmness (13.41 lbs). On the other hand, the 2016 harvest was characterized by the production of more acidic fruits, with approximately 67 meq L^{-1} of total acidity, followed by the 2013, 2014 and 2015 crops, showing the influence of environmental conditions on fruit quality and not of orchard densification. The reduction in total acidity during fruit maturation stage occurs because organic acids are degraded, which increases sugar accumulation (ETIENNE et al., 2013) and is also related to the number of fruits per plant that may alter the final accumulation of this component (OLIVEIRA et al., 2017).

The pH of the fruits did not change with the different treatments (Table 5). Among the harvests, the 2014 and 2015 crops stood out. In general, all treatments for these years presented values superior to the other years, as well as in 2013 for the treatments with two scaffolds and 0.75 m and 1.0 m, with pH values between 3.98 to 4.11, which shows the presence of a crop effect. Broadly, fruit coloration was also more intense in the 2014 and 2015 crops, as well as in 2013 (T2) and 2016 (T2, T3 and T8), with average scales of 3 to 4. Carvalho et al. (2015) showed that there are variations of fruit pH in consecutive years due to environmental conditions of production.

Table 1. Relative air humidity (%), mean maximum and minimum temperatures (°C), mean temperature (° C), sum of annual precipitation (mm) and accumulation of cold hours below 7.2 °C in the cultivation site of 'BRS Rubimel' peach in the 2013, 2014, 2015 and 2016 harvests.

	Relative humidity (%)	Average of the maximum temperatures (°C)	Average of the minimum temperatures (°C)	Average of the average temperatures (°C)	Precipitation (mm)	Cold hours (≤ 7,2°C)
2013	74.4	30.5	6.2	18.8	1841.4	487.0
2014	73.9	30.8	7.0	19.9	2000.1	246.0
2015	79.4	30.7	8.3	20.0	2265.9	92.6
2016	78.6	30.7	4.3	19.0	1661.8	487.2

Table 2. Number of 'BRS Rubimel' peach fruits harvested in the crops of 2013, 2014, 2015 and 2016 according to the number of different scaffolds and spacings.

No. Scaffolds	Spacing (m)	Number of fruits							
		2013		2014		2015		2016	
2	0.75	48.74	Ac*	106.20	BCDb	148.20	Ea	170.00	BCa
2	1.00	41.94	Ad	101.60	Dc	166.30	DEa	133.60	Db
2	1.25	38.74	Ac	99.20	Db	181.10	DEa	159.30	CDa
2	1.50	44.86	Ad	104.60	CDc	195.40	CDa	165.70	BCDb
4	1.00	56.34	Ac	140.60	ABb	198.10	CDa	152.30	CDb
4	1.50	63.34	Ac	138.00	ABCb	226.30	BCa	197.10	Aba
4	1.75	61.32	Ac	153.60	Ab	251.90	ABa	225.60	Aa
4	2.00	52.88	Ad	160.20	Ac	280.20	Aa	228.20	Ab

*Means followed by the same letter, lowercase in the row and upper case in the column, do not differ from each other by the Tukey Test, at a 5% error probability level. Coefficient of variation of 12.72%.

Table 3. Production per plant (kg) and productivity (t ha^{-1}) of peach fruits 'BRS Rubimel' in harvests (2013, 2014, 2015 and 2016), number of scaffolds and different spacing.

No. Scaffolds	Spacing (m)	Production per plant 2013	2014	2015	2016	Productivity 2013	2014	2015	2016	Soma**
2	0.75	6.4 ABc*	12.8 Bb	14.6 Db	18.5 CDa	17.1Ad	34.1 Ac	38.8 Ab	49.2 Aa	139.2 A
2	1.00	5.4 ABc	12.8 Bb	15.8 CDa	16.2 Da	10.8BCc	25.7 Bb	31.5 Aa	32.5 BCa	100.5 C
2	1.25	5.0 Bc	11.6 Bb	18.0 CDa	19.2 CDa	8.0 Cc	18.6 Cb	28.8 BCa	30.7 CDa	86.1 De
2	1.50	5.8 ABc	12.8 Bb	18.7 BCa	19.8 Ca	7.8 Cc	17.1 Cb	25.0 Ca	26.4 Da	76.3 E
4	1.00	7.6 ABb	17.8 Aa	18.7 BCa	18.5 CDa	15.3ABb	35.7 Aa	37.3 Aa	37.0 Ba	125.3 B
4	1.50	8.0 ABc	16.5 Ab	21.6 Ba	23.7 Ba	10.7BCc	22.0 BCb	28.8 BCa	31.7 Ca	93.2 Cd
4	1.75	8.3 Ac	18.0 Ab	25.2 Aa	27.6 Aa	9.4 Cc	20.6 Cb	28.8 BCa	31.6 Ca	90.4 Cd
4	2.00	6.8 ABc	19.2 Ab	27.6 Aa	28.8 Aa	6.8 Cc	19.2 Cb	27.7 BCa	28.8 CDa	88.5 Cde

*Means followed by the same letter, lowercase in the row and uppercase in the column, do not differ from each other by the Tukey Test, at a 5% error probability level. ** Means followed by the same letter in the column, do not differ by Tukey's test, at a level of 5% of error probability. Coefficient of variation of 10.23% for production per plant and 10.39% for productivity.

Table 4. Fresh weight (g), total soluble solids content (ºBrix), total acidity (meq L^{-1}) and firmness of pulp (pounds) of 'BRS Rubimel' peach fruits in crops (2013, 2014, 2015 and 2016), number of scaffolds and different spacings.

No. Scaffolds	Spacing (m)	Fresh Mass		Total soluble solids		Total acidity		Pulp Firmness	
2	0.75	114.87	ns	10.29	ns	50.18	ns	12.19	ns
2	1.00	117.72		10.21		50.58		12.00	
2	1.25	116.76		10.13		51.26		12.31	
2	1.50	117.09		10.23		50.54		12.37	
4	1.00	120.01		10.14		49.35		12.26	
4	1.50	115.74		10.27		48.99		12.46	
4	1.75	119.12		10.27		49.97		12.45	
4	2.00	118.62		10.18		50.96		12.31	
Year									
2013		130.51	a*	10.95	a	50.22	b	13.41	a
2014		121.44	b	10.10	b	44.13	c	11.41	c
2015		97.37	c	9.89	b	39.93	d	12.53	b
2016		120.65	b	9.92	b	66.63	a	11.83	c
CV (%)		6.95		4.52		11.02		7.45	

* Means followed by the same letter, lowercase in the column, do not differ from each other by the Tukey test, at a 5% error probability level. ns: not significant.

Table 5. pH and color (color scale 1 to 4) of peach fruits 'BRS Rubimel' in harvests (2013, 2014, 2015 and 2016), number of scaffolds and different spacing.

No. of Scaffolds	Spacing (m)	pH 2013	2014	2015	2016	Coloring 2013	2014	2015	2016
2	0.75	4.10 Aa*	4.10 Aa	3.98 Aa	3.68 Ab	3.0 ABab	3.0 Aab	4.0 Aa	3.0 Ab
2	1.00	4.07 Aa	4.06 Aa	3.99 Aa	3.72 Ab	3.4 Aa	3.0 Aa	3.0 Aa	3.0 Aa
2	1.25	3.96 ABCDa	4.05 Aa	4.01 Aa	3.76 Ab	3.2 ABa	3.0 Aa	4.0 Aa	3.0 Aa
2	1.50	3.84 Db	4.06 Aa	4.01 Aa	3.74 Ab	2.2 Bb	3.0 Aa	3.0 Aa	3.0 Aab
4	1.00	3.89 BCDb	4.11 Aa	3.96 Ab	3.75 Ac	3.2 ABab	3.0 Aab	4.0 Aa	2.0 Ab
4	1.50	4.04 ABa	4.05 Aa	4.00 Aa	3.71 Ab	2.6 ABbc	3.0 Aab	4.0 Aa	2.0 Ac
4	1.75	4.00 ABCa	4.06 Aa	4.01 Aa	3.72 Ab	2.4 ABb	3.0 Aa	3.0 Aab	2.0 Ab
4	2.00	3.88 CDb	4.07 Aa	4.00 Aab	3.72 Ac	2.4 ABa	3.0 Aa	3.0 Aa	3.0 Aa

* Means followed by the same letter, lowercase in the row and uppercase in the column, do not differ from each other by the Tukey Test, at a 5% error probability level. Coefficient of variation of 1.99% for pH and 3.77% for coloring.

Conclusion

Orchard densification is feasible for peach trees of the 'BRS Rubimel' cultivar due to the increase in productivity, without decreasing the quality of the fruits, with a spacing of 0.75 cm between plants and two scaffolds being indicated.

The use of the four-scaffold training system is another option indicated due to the maintenance of high productivity and the reduction in the number of plants per hectare in relation to the two-scaffold treatments.

Acknowledgement

The authors would like to thank the Research and Innovation Support Foundation of the State of Santa Catarina (FAPESC) for financing the project; the Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI) - Experimental Station at Videira/SC for the structure and the Ferronato family, for the availability of the orchard for conducting the experiments.

References

ALMEIDA, G.K. de; MAGRIN, F.P.; SOLDATELLI, P.; FIORAVANÇO, J.C. Fenologia e produtividade de cultivares de pessegueiro. **Revista de Ciências Agroveterinárias**, Lages, v.13, p.255-265, 2014.

ALVARES, C.A.; STAPE, J.L.; SENTELHAS, P.C.; MORAES GONÇALVES, J.L.; SPAROVEK, G. Köppen"s climate classification map for Brazil. **Meteorologische Zeitschrift**, Sttugart, v.22, n.6, p.711–728, 2013.

CARVALHO, R.I.N.; SORRENTI, G.; ROSA, S.L.K.; VENDRAMIN, D.W.; ALVES, M.C.B.; SPERLING, C. Poda verde e produção do pessegueiro em alta densidade. **Revista Eletrônica Científica da UERGS**, Porto Alegre, v.1, n.1, p.3-7, 2015.

CHENG, J.; LIAO, L.; ZHOU, H.; GU, C.; WANG, L.; YAN, Y. A small indel mutation in an anthocyanin transporter causes variegated colouration of peach flowers. **Journal of Experimental Botany**, Lancaster, v.66, n.22, p.7227-7239, 2015.

EPAGRI/CIRAM. **Agroconnect**. Disponível em: http://www.ciram.sc.gov.br/agroconnect/. Acesso em: 15 jun. 2018.

ETIENNE, A.; GÉNARD, M.; LOBIT, P.; MBEGUIÉ-A-MBÉGUIÉ, D.; BUGAUD, C. What controls fleshy fruit acidity? A review of malate and citrate accumulation in fruit cells. **Journal of Experimental Botany**, Lancaster, v.64, p.1451-1469, 2013.

FERREIRA, L.V.; PICOLOTTO, L.; PEREIRA, I.S.; SCHMITZ, J.D.; ANTUNES, L.E.C. Nitrogen fertilization in consecutive cycles and its impact on high-density peach crops. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.53, n.2, p.172-181, 2018.

GALARÇA, S.P.; FACHINELLO, J.C.; BETEMPS, D.L.; HOFFMAN, A.; MARODIN, G.A.B.; PRETTO, A.; NUNES, F.S.; DIAS, F.P. Crescimento e desenvolvimento de pessegueiros 'Chimarrita' e 'Maciel' sobre diferentes porta-enxertos e locais de cultivo. **Ciência Rural**, Santa Maria, v.43, n.2, p.219-224, 2013.

GLENN, D.M.; TWORKOSKI, T.; SCORZA, R.; MILLER, S.S. Long-term effects of peach production systems for standard and pillar growth types on yield and economic parameters. **HortTechnology**, Alexandria, v.21, p.720-725, 2011.

HOZA D.; DELIAN, E.; ASANICA, A.; HOZA, G. Research regarding the intensity of certain physiological processes for peach varieties within high density plantations. **Agriculture and Agricultural Science Procedia**, Amsterdam, v.6, p.165-170, 2015.

MAAS, F. Evaluation of *pyrus* and quince rootstocks for high density pear orchards. **Acta Horticulturae**, The Hague, v.800, p.599-610, 2008.

MAYER, N.A.; NEVES, T.R. das; ROCHA, C.T.; SILVA, V. A.L. da. Adensamento de plantio em pessegueiros 'Chimarrita'. **Revista de Ciências Agroveterinárias**, Lages, v.15, p.50-59, 2016.

MAYER, N.A.; PEREIRA, F.M. Produtividade de pessegueiros 'Aurora-1' em diferentes espaçamentos e métodos de propagação do porta-enxerto 'Okinawa'. **Bragantia**, Campinas, v.71, p.372-376, 2012.

MAYER, N.A.; PEREIRA, F.M.; REIGHARD, G.L. Prunus mume clones as rootstocks for 'Aurora-1' peach in São Paulo State, Brazil and planting density. **Acta Horticulturae**, The Hague, v.1058, p.619-626, 2014.

OLIVEIRA, P.D.; MARODIN, G.A.B.; ALMEIDA, G.K.; GONZATTO, M.P.; DARDE, D.C. Heading of shoots and hand thinning of flowers and fruits on 'BRS Kampai' peach trees. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.52, n.11, p.1006-1016, 2017.

PASA, M.S.; FACHINELLO, J.C.; SCHMITZ, J.D.; ROSA JÚNIOR, H. F.; FRANCESCHI, É.; CARRA, B.; GIOVANAZ, M.A.; SILVA, C.P. Early performance of ‘Kampai’ and ‘Rubimel’ peach on 3 training systems. **Bragantia**, Campinas, v.76, n.1, p.82-85, 2017.

PRAMANICK, K.K.; KISHORE, D.K.; SINGH, R.; KUMAR, J. Performance of apple (*Malus x domestica* Borkh) cv. ‘Red Spur’ on a new apple rootstock in high density planting. **Scientia Horticulturae**, New York, v.133, p.37-39, 2012.

SOUZA, A.L.K.; SCHUCH, M.W.; CAMARGO, S.S.; PEREIRA, R.R.; SOUZA, E.L.; PASA, M.S. Does propagation method affect the field performance of peach trees? **Semina: Ciências Agrárias**, Londrina, v.38, n.4, p.2815-2822, 2017.

TOMAZ, Z.T.; LIMA, C.S.M.; GONÇALVES, M.A.; RUFATO, L.; RUFATO, A.R. Crescimento vegetativo, floração e frutificação efetiva do pessegueiro ‘Jubileu’ submetido a diferentes comprimentos de interenxertos. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.45, n.9, p.973-979, 2010.

TUSTIN, D.S. Future orchard planting systems - Do we need another revolution. **Acta Horticulturae**, The Hague, v.1058, p.27-36, 2014.