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PLANT BREEDING - Note

Y-shaped and fruiting wall peach orchard training system in subtropical Brazil

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ABSTRACT: Peach as commercial crop in Brazil is usually grown in open vase training system. However, in the 1970s large orchards changed to the Y-shaped system and higher density of plants. This system is the most used in São Paulo state because it allows orchard densification. However, the longevity of the trees is reduced from 15 to 8 years being the excessive exposure of internal branches to solar radiation the main reason for the reduction. Aiming to offer new alternatives of training system for peach, an experiment was carried out to evaluate the fruiting wall in comparison to Y-shaped, using the cultivar Tropic Beauty budded onto cultivar Okinawa. Ten plants by treatment were used as repetition and microclimatic equipment was installed inside the plant to measure temperature and solar radiation. Values of soluble solids (°Brix) were 9.64 to fruiting wall and 9.59 to Y-shaped, not statistically different. However most of fruit physicochemical characteristics were favorable to the fruiting wall system: fruit weight (g) – 97.56 and 90.44; pulp yield (g) – 92.42 and 85.70; pulp firmness ($Kg \cdot cm^{-2}$) – 4.27 and 3.50; titratable acidity (g citric ac.·100 ml^{-1}) – 0.76 and 0.71; and ratio – 12.79 and 13.58, respectively to fruiting wall and Y-shaped. Solar radiation transmission and maximum daily temperature values for the Y-shaped were higher when compared to fruiting wall at harvest. The obtained data show that the fruiting wall training system could be an alternative to Brazilian's growers for producing superior fruit quality without yield reduction.

Key words: yield, soluble solids, titratable acidity, Tropic Beauty, Okinawa.

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In Brazil, peach orchards are cultivated in the southern and southeast states, where 57% is destined for *in natura* consumption and 43% for industrialization. Rio Grande do Sul state is the largest producer accounting for 60% of the Brazilian production, well distributed to both destinations, while São Paulo, second in ranking, has the production of 17.3% (IBGE 2013), most for *in natura* consumption. Brazilian imports of peaches and nectarines grew in volume from 7,477 in 2004 to 22,872 t in 2013 (305.9%), while in terms of price the increase was around 6.3 times (FAO 2018). Data from IBGE (2018) show that from 2014 to 2015, production grew by 2.4% in volume and 18.3% in price.

Advances in research provide knowledge that contribute to the development of pruning and training techniques – using two or three-dimensional canopy – aiming to reduce the plant juvenile period and to increase the uniformity of fruit crop (Pereira and Raseira 2014). The open vase training system was traditionally used in Brazil, mainly in the southern region. In this system, the canopy consists of four to six scaffolds with an open center. From the main branches will blossom out the productive branches. This system has the advantage of providing a good productive area and allowing the shortening of the branches so that it is not necessary to use ladders or platforms for pruning, thinning and harvest (Franzon and Raseira 2014). However, it has been replaced for not allowing high density planting (400 pl./ha), presenting low initial productivity and interfering in some cultural practices, such as mowing, due to presence of low branches (Pereira and Raseira 2014).

There are other training systems suitable for use in peach crop. One of the most popular training systems is the Y-shaped (Fig. 1), as well as its modifications. The system consists of training two or four scaffold branches (single Y or double Y), which almost touch each other in the center of the row (Pereira and Raseira 2014). This training system was widely adopted by producers in the state of São Paulo since the 1970s, mainly because it allowed high-density orchards (2,000 pl./ha). As disadvantages, it needs constant green pruning and does not allow the adoption of some mechanized cultural practices, such as pruning and thinning. Another disadvantage is the reduction of economic longevity of the orchard due to the excessive exposure to sun beams in the inner face of the scaffold branches.

In the search for technologies that allow the production of high quality peaches and yield and reduction of damages caused by the burning of main branches in the Y-shaped, the fruiting wall (Fig. 1) is an option for the producers. In the fruiting wall, which is a multi-leader system, the trees →

Figure 1. Comparison of training systems: Y-shaped and fruiting wall. Photograph of experimental area at the municipality of Jarinu, São Paulo state, Brazil.

are trained bending the scaffolds in the direction of the row: four to six scaffolds are grown vertically from a low horizontal cordon. Despite the need for manpower for orchard establishment, it allows mechanical cultivation, an advantage in regions where there is lack of hand labor. In addition, the narrow canopy allows good light penetration favoring fruit color and quality.

Besides the possibility of high density planting, the choice of the training system should take into account factors that influence yield, such as the orchard architecture (shape and orientation of the trees), which affects light interception and temperature, directly related to the photosynthetic capacity (Corelli-Grappadelli and Marini 2008). Studies show that the distribution of light in the canopy differs depending on the training system, but that in all of them light penetration is reduced rapidly from the perimeter to the center of the canopy. Regarding temperature, DeJong and Moing (2008) report that the ideal temperature for peach tree photosynthesis varies from 20 to 32 °C, and values outside this range may inhibit the process.

Taking into account the above considerations, an experiment to compare the fruiting wall and Y-shaped training systems was ran in a commercial production area in the municipality of Jarinu, state of São Paulo, Brazil. The orchard is located at 870 m altitude at the geographic coordinates: 23°04'48" South and 46°43'37" West. The climate is classified as Cwb (Köppen), with cold and dry winters and mild and rainy summers.

Three years-old plants of Tropic Beauty cultivar budded on Okinawa rootstock were used in this study. The spacing between rows was 3.5 m for both training systems. The spacing between trees was 4.0 m for the fruiting wall and 2.0 meters for the Y-shaped. Tropic Beauty produces medium size fruits (between 80 and 100 g) with 70% red over a yellow skin. The pulp is yellow with red spots close to the core and of medium firmness. The taste is mostly acidic and soluble solids range between 7.5 and 11.0 °Brix (Raseira et al. 2014). It is recommended for subtropical regions because it presents low chill requirement, around 150 units. It is widely planted in São Paulo state because it is an early ripening cultivar with cycle of 89 days (Ferguson et al. 2007).

To characterize the orchard microclimate, measurements of global solar radiation were taken above crop canopy using Licor-LI200 sensors and inside the plants by 1 m long linear solarimeters. The air temperature was measured by copper-constantan thermocouples placed inside microclimatic shelters (Campbell Scientific). Solar radiation and temperature sensors were also placed at the height of the lower third of the plants for both training systems. The sensors were coupled to automatic data acquisition system (Campbell Scientific Inc., CR10X), programmed for readings every minute and obtaining the average hourly values (solar radiation) and daily extremes values.

Phenological observations were performed twice a week from the end of dormancy period until harvest (commercial ripening) using the scale developed by E. Bellini (Bassi and Monet 2008). Observations were taken on the lower third of the canopy, using a sample of 10 plants for each training system.

On 2017 growing season 24 fruits were randomly collected from each of the 10 sampling plants of each training system to evaluate: fruit and pulp weight (total weight minus seed weight); flesh firmness; total soluble solids (SS); and titratable acidity (TA) by the Instituto Adolfo Lutz method (2008).

Fruit weight, firmness and pulp weight were measured in 240 fruits individually, whereas the SS and TA were evaluated in samples composed by 24 fruits per plant, subdivided in four replications of six fruits.

Yield was estimated by number of fruits in each tree multiplied by the average fruit weight of which respective plant and by the density of trees in each treatment (Y-shaped: 1,430 trees·ha^{-1}; Fruiting wall: 715 trees·ha^{-1}). The design was completely randomized and the average values were compared by the t test using the R program (R Development Core Team 2009).

The rainfall during the crop cycle was 112 mm, as normally occurs at this time of the year in the region, while the winter is drier. Maximum temperatures at the beginning of the crop cycle were around 22.0 °C and above 30.0 °C at harvest, while the minimum temperatures averaged from 11.0 °C to 13.5 °C (Fig. 2).

It was observed that the maximum (22.7 and 22.9 °C) and minimum (10.8 and 10.9 °C) temperatures inside the plants at time of flowering were similar for both training systems. On the other hand, at harvest, the values of maximum temperatures in the Y-shaped were 0.7 °C higher when compared to the fruiting wall (27.3 °C), with the difference between the training systems being significant by the t test.

Regarding to transmission of solar radiation to the lower third of the plants for the different training systems, at the flowering period, the values ranged from 80% to 95%, regardless the time of the day since plants had less leaves (Fig. 3). At the maturation-harvesting period, with plants showing →

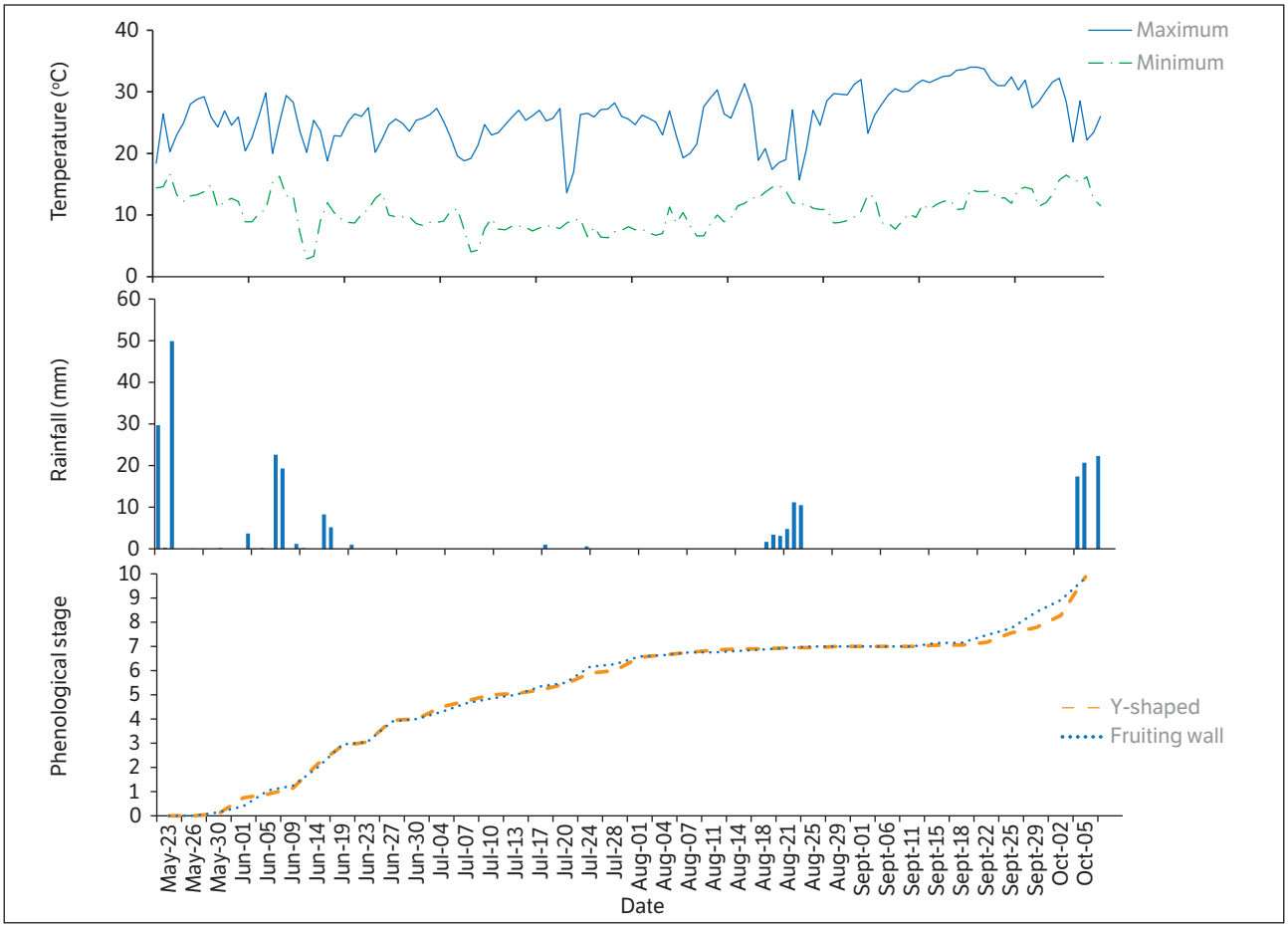

Figure 2. Maximum and minimum temperatures, rainfall and phenological stages during the growing season of 2017 of Tropic Beauty peach cultivar at the municipality of Jarinu, São Paulo state, Brazil. Phenological stages: 1 – Bud swell; 2 – Pink stage; 3 – Full bloom; 4 – Petal fall; 5 – Split-jacket; 6 – Fruit set; 7- Small fruitlets; 8 – Final swell; 9 – Fruit *veraison*; 10 – Commercial ripening.

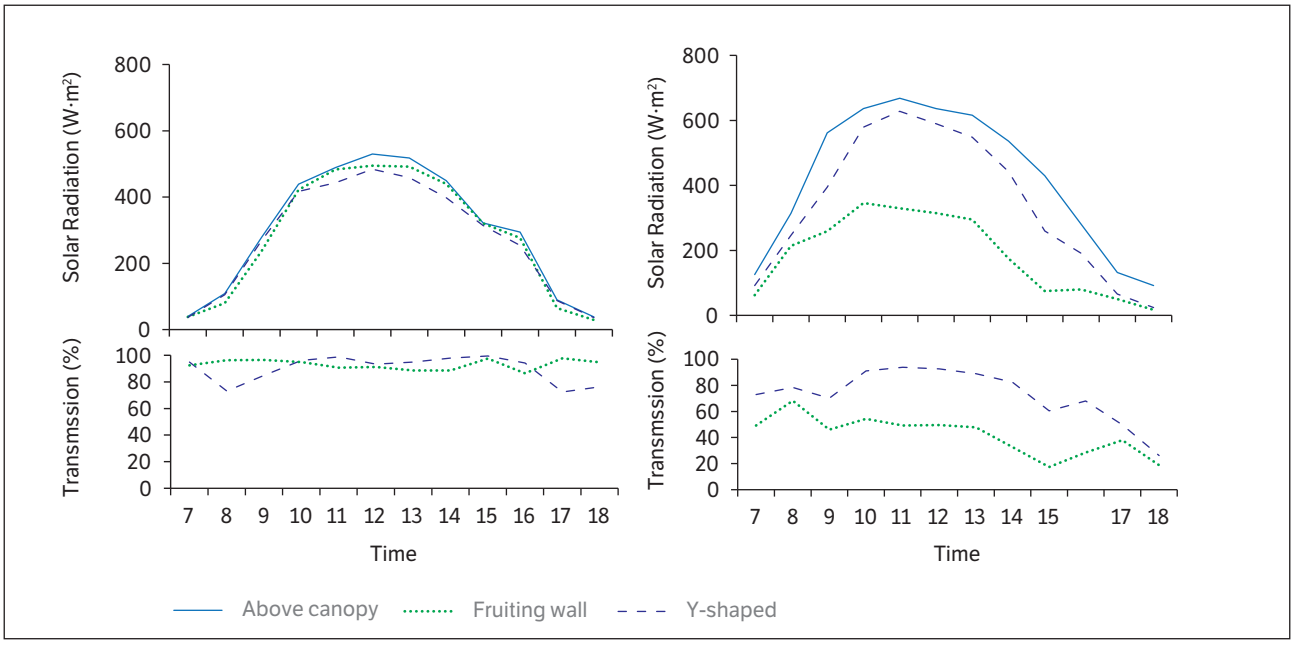

Figure 3. Solar radiation above the canopy and transmitted into Tropic Beauty peach trees trained in fruiting wall and Y-shaped systems during the flowering (left) and harvest (right) period at the municipality of Jarinu, São Paulo state, Brazil.

more dense foliage, close to noon the radiation was 40% to 60% and 60% to 90% in the fruiting wall and Y-shaped system, respectively. High solar radiation transmission values observed in the Y-shaped system may cause problems of burning in more exposed branches.

Phenological development for both training systems showed a double sigmoidal pattern (Fig. 2), as it was expected for peaches (Bruna and Moreto 2011). No significant differences were observed between the phenological stages when comparing the systems, but in stage 8 (final swell) and 9 (fruit *veraison*), the fruiting wall system showed a small anticipation.

Crop cycle duration – considered from pruning to fruit at the commercial harvest point – lasted 135 days in both systems. The fruit development period was 74 days, shorter than expected for this cultivar (89 days) (Ferguson et al. 2007), probably due to the climatic differences between the two regions.

The difference between results for yield was not significant, reached 24.12 t·ha^{-1} in the Y-shaped and 24.41 t·ha^{-1} in the fruiting wall training system (Table 1). Leonel et al. (2011) obtained yield of 19.75 t·ha^{-1} in the Y-shaped, while Souza et al. (2013) estimated between 19.30 and 26.60 t·ha^{-1}, both in an orchard with density of 417 trees.ha^{-1}.

The results obtained for pomological parameters in both training systems were according to what was expected for the cultivar (Table 1). Except for the SS content, all quality fruit characteristics evaluated presented significant differences. The ratio was the only parameter in which the results were not favorable to the fruiting wall training system. Raseira et al. (2014) described the cultivar as having values of fruit weight varying between 80 and 100 g and SS from 7.5 to 11.0 °Brix, similar to the values obtained in the present study.

Almeida and Durigan (2006) found lower values for SS and TA, respectively, 8.5 °Brix and 0.7 g citric ac.·100 mL^{-1}, but the relation between SS/AT was higher (12.9). Ramos and Leonel (2008) obtained fruit weight values higher to the standard for the cultivar (121.90 g), but within the expected for the other parameters (SS: 10.8 °Brix, AT: 0.96 g citric ac.·100 mL^{-1}). Leonel et al. (2014), studying the behavior of the cultivar, showed higher values for SS (12.2 and 11.0 °Brix), AT (0.81 and 0.82 g citric ac.·100 mL^{-1}), and ratio (14.4 and 14.0), respectively for the 2009 and 2010 growing seasons. However, regarding to the parameter pulp firmness, the authors found values equivalent to 2.65 and 3.19 kg.cm^{-2}, inferior to those obtained in the present study.

The relationship between the total soluble solids content and the titratable total acidity (SS/AT) content is usually used to evaluate the degree of fruit maturation as well as its taste (Lima et al. 1999). The SS/AT around 11.4 is considered indicative of a good combination of sugars and acids and good flavor for peaches (Argenta et al. 2004). In this way, the results obtained in the present study, even presenting higher values for AT, did not affect the SS/AT ratio in both training systems (Y-shaped: 13.58, Fruiting wall: 12.79).

The fruiting wall could be a viable alternative to replace the Y-shaped due to its better qualitative characteristics, as well as the reduction of the solar radiation incidence on the main branches.

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Table 1. Chemical and physical characteristics of peach fruits, cultivar Tropic Beauty budged on Okinawa, in Y-shaped and fruiting wall training systems, in the municipality of Jarinu, São Paulo state, Brazil, 2017.

Source of variation	Training system		t test
	Y-shaped	Fruiting wall	
Yield (t·ha^{-1})	24.12	24.41	Ns
Fruit weight (g)	90.44	97.56	*
Yield in pulp (g)	85.70	92.42	*
Pulp firmness (kg·cm^{-2})	3.50	4.27	*
Soluble Solids – SS (°Brix)	9.59	9.64	Ns
Titratable Acidity – TA (g citric ac.·100 ml–1)	0.71	0.76	*
Ratio (SS/TA)	13.58	12.79	*

Ns = $p > 0.05$; * $p < 0.05$

AUTHORS' CONTRIBUTION

Conceptualization, Sobierajski G. R., Hernandes J. L. and Pedro Júnior M. J.; Methodology, Sobierajski G. R., Hernandes J. L. and Pedro Júnior M. J.; Investigation, Sobierajski G. R., Pedro Júnior M. P. and Silva T. S.; Writing – Original Draft, Sobierajski G. R., Hernandes J. L. and Pedro Júnior M. J.; Writing – Review and Editing, Sobierajski G. R. and Pedro Júnior M. J.; Funding Acquisition, Sobierajski G. R.; Supervision, Sobierajski G. R.

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