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SOIL AND PLANT NUTRITION - Article

Quality peach produced in fertilizer doses of nitrogen and green pruning

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ABSTRACT: The increasing consumer demand for fruit quality justifies the development of researches that combine orchards management and consumers' perception of the quality of the product. The aim of this study was to evaluate the effect of nitrogen fertilization combined with green pruning intensity on fruit quality of 'Chimarrita' from high density peach trees during three consecutive harvest seasons. For this purpose, urea composed of different nitrogen rates (0, 40, 80, 120, 160, 200 and 240 kg·ha^{-1}·year^{-1}) was applied, under two intensities of green pruning (annual – once per season; or continuous – four times per season) in a factorial scheme (7 × 2). Fruits have been subjected to physical, chemical and sensorial analysis, made by 60 non-trained evaluators in each of the harvest seasons. The results showed that the cumulative effect of applying N in the third harvest season improved SS attributes, SS/TA ratio and fruit skin color to the dose of N of 148 kg·ha^{-1}·year^{-1}. There is no difference between green pruning intensity and peach fruit quality.

Key words: *Prunus persica*, mineral nutrition, fruit quality, post-harvest, organoleptic.

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INTRODUCTION

Nitrogen (N) is the nutrient required and exported in greater quantities by the peach tree. It has direct effect on vegetative growth, yield and fruit quality, therefore the setting of the dose is necessary to ensure the best nutritional balance, replacing the exported quantity and maintaining the proportion between vegetative and reproductive growth. In addition to the dose, application times and the managements adopted in the culture can also affect the response of the applied nitrogen (Dolinski et al. 2005; Jia et al. 2006; Dolinski et al. 2007; Brunetto et al. 2007; Ernani et al. 2008; Cuquel et al. 2011; Falguera et al. 2012; Olivos et al. 2012; Pascual et al. 2013; Souza et al. 2013).

Among the managements, green pruning is adopted by the integrated production of peaches for the canopy volume conduction (Fachinello et al. 2003). The intensity of this pruning can be changed depending on the response to the amount of nitrogen applied, since this nutrient has a direct effect on the quantity and/or strength of branches, including waterspouts (Mattos et al. 1991; Daane et al. 1995), which represent the highest percentage of removed branches during this practice. The removal of these branches contributes to the better use of nitrogen by productive branches to stimulate the development of flowering buds.

In addition to the direct effects of fertilization, the higher vegetative stimulus due to nitrogen application implies on indirect effects, such as reduction in solar radiation incidence and in the application of pesticides efficiency, besides changes the microclimate in canopy's interior.

Flavor, aroma and texture are the characteristics for peach sensory profiling observed by consumers (Cuquel et al. 2012). The response variations resulting from N increment can be evidenced in the quality of peaches by the change in skin color, with N resulting in an increase in the content of the skin pigments (Olienyk et al. 1997), or in reduction (Daane et al. 1995; Souza et al. 2013), or even in keeping it unaltered (Ernani et al. 2008; Falguera et al. 2012).

The roles performed individually by nitrogen and green pruning in the fruits are known; however, the understanding on the interaction between them in fruit quality is incipient in peach orchards.

Given the above, this study aimed to evaluate the effect of nitrogen fertilization and green pruning intensity on the quality of high density 'Chimarrita' peach fruits, in the course of three consecutive harvest seasons.

MATERIALS AND METHODS

The experiment was conducted in a four years old high density orchard of 'Chimarrita' peach on 'Okinawa' rootstock, located in the municipality of Fazenda Rio Grande, PR (lat 25°37'32"S, long 49°15'29"W). Local altitude is 900 m and the climate, according to Köppen classification, is Cfb type (subtropical humid).

The experimental area consisted of 784 plants that were conducted with two major scaffolds, in "Y" conduction system, spaced 5 m between rows and 1 m between plants, totaling 0.40 ha. Soil analysis presented pH ($CaCl_2$) = 5.4; Al^{3+}= 0.0; Ca^{2+} = 5.1 $cmol_c \cdot dm^{-3}$; Mg^{2+} = 3.0 $cmol_c \cdot dm^{-3}$; K^+ = 0.49 $cmol_c \cdot dm^{-3}$; P= 7.9 $mg \cdot dm^{-3}$ (Mehlich Extraction); organic matter = 60.4 $g \cdot mg^{-3}$; cation exchange capacity (CEC) = 13.2 $cmol_c \cdot dm^{-3}$ and base saturation (V) = 65%.

The experimental design was a randomized block design and the treatments distributed in a 7 × 2 factorial, the first factor consisting of nitrogen fertilization doses and the second factor consisting of green pruning intensities, with three replications. The experimental plot consisted of four plants separated by four other boundary plants on the line, and a boundary line separating the blocks (totaling seven rows of plants).

Nitrogen fertilization levels were applied in the amounts of 40, 80, 120, 160, 200 e 240 kg de $N \cdot ha^{-1} \cdot year^{-1}$ as urea in quantity enough to cover the ground in the projection of the canopy, at a 30 cm distance from the stem, and the control did not receive nitrogen fertilizer. Doses were parceled at the beginning of budburst (30%), after thinning (30%) and after harvest (40%), according to the norms of Integrated Fruit Production (INMET). The fertilization treatments were applied from the implementation of the orchard (2005), except in 2007/08, when it was applied to a dose of 100 kg $N \cdot ha^{-1}$ homogeneously in the experimental area.

The intensity of green pruning, annual green pruning (AGP) and continuous green pruning (CGP), were made withdrawing waterspouts and poorly placed branches. AGP was performed once per harvest season beginning in 2008/2009 in March. CGP was held four times per harvest season from 2008/2009 (October, November, December and March).

Evaluations were accomplished for three consecutive harvest seasons (2008/2009; 2009/2010 and 2010/2011). For physical and chemical characterization, experimental unit was composed of five fruits, performing the following →

analyzes: firmness, determined using penetrometer with eight mm needle, expressed in Newton (N); titratable acidity (TA) by titration with 0.1N NaOH of 10 ml of fruit juice diluted in 100 mL distilled and deionized water until pH 8.1 and expressed in % of malic acid; soluble solids (SS), determined by refractometry and expressed in °Brix; epidermal background color, determined with a colorimeter Minolta®, the brand expressed in °Hue; and SS/TA ratio was calculated using the results obtained for the SS content (°Brix) and TA (% malic acid) of the same sample by dividing the values by each other. Five fruits were used per sample.

To carry out the sensorial analysis, a descriptive test for the evaluation of attributes was used, with a team consisting of 60 untrained evaluators assessed for each harvest season. Attributes of appearance, color, aroma, texture, juiciness and flavor were evaluated by making use of non-structured scales of 9 cm, whose left end represents "disliked very much" and the far right represents "liked very much". Samples were submitted to the evaluators coded with three random digits. Each judge evaluated 7 samples, each sample comprising a peach fruit for the evaluation of appearance, color and aroma. For the other attributes (texture, juiciness and flavor) about 20 grams of the peach fruit were used as a sample.

Results were submitted to analysis of variance, and, when the effects were significant for the nitrogen doses factor, regression equations were adjusted, being tested linear and quadratic models by F test, from which was chosen the one with most significance ($p< 0.05$). For the factor intensity of green pruning, the means were compared by Tukey test ($p< 0.05$).

RESULTS AND DISCUSSION

Regarding the physical, chemical and sensorial characteristics, no interaction was observed between the nitrogen fertilization levels and pruning intensities. However, it is possible to observe the effect of nitrogen fertilization on the physical and chemical attributes evaluated, with different responses during the three harvest seasons.

In the first two crop seasons, soluble solids (SS), titratable acidity (TA) and SS/TA ratio did not differ between nitrogen fertilization doses (Table 1). This behavior has been observed in several studies, even when this nutrient affected productivity, number of fruits (Olienyk et al. 1997; Dolinski et al. 2005) and N content in peach fruit (Brunetto et al. 2007).

The lack of response of N on fruit quality can be partly attributed to the high content of organic matter in the soil (60.4 $g \cdot mg^{-3}$). Such behavior corroborates studies in peach and apple trees fertilized with high doses of N (Dolinski et al. 2005; Brunetto et al. 2007; Ernani et al. 2008; Baldi et al. 2014). Added to the organic N present in the soil, the carbohydrate reserves from the previous harvest season →

Table 1. Pulp firmness (PF), titratable acidity (TA), solid soluble content (SS), SS/TA ratio of 'Chimarrita' peach (*Prunus persica*), evaluated three days after harvest, during three consecutive harvest seasons, under different nitrogen fertilization doses and green pruning intensities.

N Dose[1]	PF (N)			SS (Brix %)			TA (% citric acid)			SS/AT ratio		
	2008/ 2009	2009/ 2010	2010/ 2011	2008/ 2009	2009/ 2010	2010/ 2011	2008/ 2009	2009/ 2010	2010/ 2011	2008/ 2009	2009/ 2010	2010/ 2011
0	0.76 ns	1.43 ns	1.81 ns	8.26ns	7.93ns	8.47*	0.47 ns	0.42 ns	0.53 ns	1.18 ns	1.33 ns	1.00*
40	2.73	1.53	3.11	7.92	7.82	8.82	0.43	0.47	0.57	1.22	1.12	1.04
80	0.88	1.61	3.13	8.27	7.28	9.58	0.44	0.45	0.57	1.26	1.10	1.12
120	1.88	2.2	2.73	8.27	7.65	10.08	0.53	0.44	0.54	1.07	1.17	1.24
160	1.37	1.69	3.22	8.58	7.2	9.87	0.47	0.42	0.55	1.24	1.17	1.22
200	2.73	1.95	2.82	8.22	7.77	9.50	0.52	0.48	0.55	1.12	1.09	1.17
240	2.03	2.05	3.80	8.38	6.67	9.35	0.43	0.45	0.59	1.36	1.02	1.07
AGP[2, ns]	1.23	1.78	2.72	8.21	7.48	9.49	0.45	0.45	0.54	1.22	1.09	1.16
CGP[3]	2.30	1.77	3.16	8.32	7.52	9.32	0.48	0.43	0.56	1.18	1.18	1.11
CV (%)[4]	51.25	49.53	53.65	12.05	20.07	10.75	19.19	15.52	12.02	22.07	27.17	16.59

[1]kg of $N \cdot ha^{-1} \cdot year^{-1}$. [2]Anual Green Pruning. [3]Continuous Green Pruning. [4]Coefficient of Variation. nsNot significant. *Significant by Tukey test at 5% probability.

and/or distribution of N in the plant (branches and roots) may be sufficient, with no reduction in the concentration of these nutrients in the peach tree roots even in periods of high demand (Araújo et al. 2008). Therefore, these amounts of nitrogen can ensure the quality of the fruits, even without the application of this nutrient (Santos et al. 2010; Olivos et al. 2012).

In the three crop seasons evaluated, there were no differences in the physical, chemical and sensorial attributes of peach fruits subjected to different intensities of green pruning. Also, the frequency of green pruning showed no interaction with nitrogen fertilization (Tables 1 and 2). Green pruning recommended by peach integrated production could be used for other purposes, such as to improve the luminosity and aeration of the canopy, to control excessive vegetative growth, to reduce the incidence of diseases and to facilitate cultural practices (Tutida et al. 2007; Tratch et al. 2010; Santarosa et al. 2013). However, the use of higher intensity of green pruning (CGP) should not be recommended if the purpose was only to improve the quality of the fruit, due to the costs for its implementation.

As for the third harvest, effect of different treatments on the SS content and SS / TA ratio was observed (Figure 1a, 1b). For the calculated N rate (143 kg·ha^{-1}·year^{-1}), a maximum of SS 9.78 °Brix value was obtained, close to those advocated by Raseira and Nakasu (1998) for Chimarrita peaches (12 to 15 °Brix) and still the maximum SS/TA ratio for the calculated dose of 148 kg N·ha^{-1}·year^{-1} was achieved. It should be noted that the soluble solids values can be influenced by the cumulative effect of nitrogen application over the

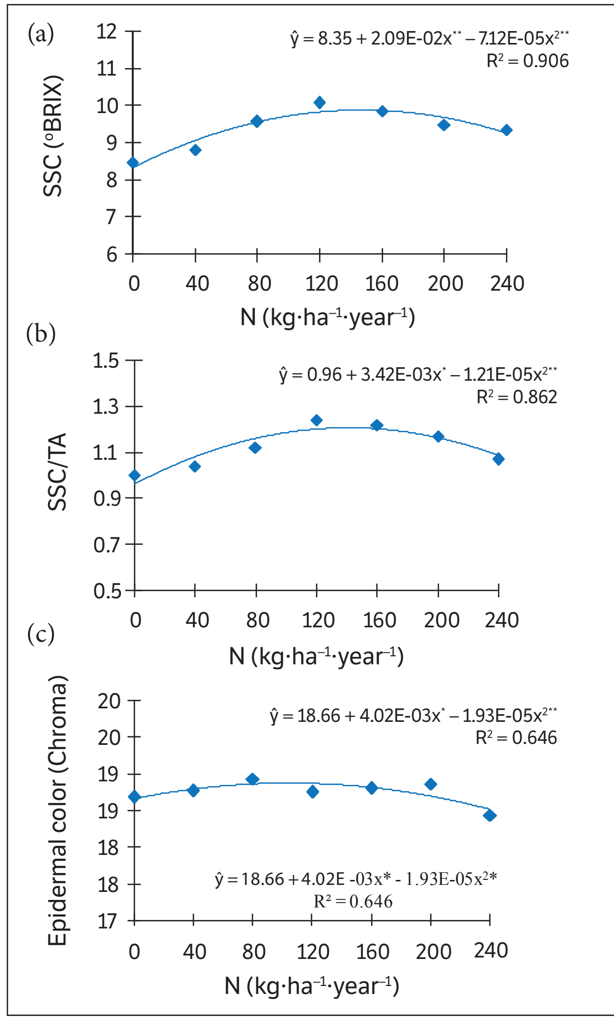

Figure 1. Soluble solids, SS/TA ratio and epidermal color (Chroma) of 'Chimarrita' peach (*Prunus persica*) under nitrogen fertilization doses produced in the 2010/2011 harvest season.

Table 2. Epidermis coloring (chroma and hue angle) of 'Chimarrita' peach fruits (*Prunus persica*), three days after harvest for three consecutive harvest seasons, under different nitrogen fertilization doses and green pruning intensities.

Dose of N	Chromaticity			°Hue		
	2008/2009	2009/2010	2010/2011	2008/2009	2009/2010	2010/2011
0	37.29*	17.17 ns	18.68*	67.49 ns	60.24 ns	64.82 ns
40	38.59	17.21	18.77	59.58	68.00	70.89
80	37.26	17.06	18.93	49.54	63.66	74.70
120	38.38	17.65	18.75	74.48	70.57	71.64
160	36.59	16.81	18.80	46.81	63.47	72.10
200	36.88	17.62	18.86	52.37	72.97	72.58
240	35.46	17.49	18.44	46.33	58.14	75.41
PVA[2, ns]	36.83	17.32	18.66	92.80	81.58	91.67
PVC[3]	37.57	17.24	18.83	94.05	82.66	92.32
CV (%)[4]	5.44	2.60	2.77	6.74	4.13	2.80

[1]kg of N·ha^{-1}·year^{-1}. [2]Anual Green Pruning. [3]Continuous Green Pruning. [4]Coefficient of Variation. [ns]Not significant. *Significant by Tukey test at 5% probability.

harvest seasons, which promotes greater vegetative growth, increased leaf area and/or number of leaves, resulting in higher photosynthetic capacity of the plant and consequently, increased photoassimilates synthesis (Carvalho et al. 1989).

Fruit epidermis coloring was not affected by the application of up to 240 kg·N·ha^{-1} (Table 2) evaluated in the first two harvests. As for the third assessed harvest season, a quadratic behavior in chromaticity with respect to N doses was observed, and the highest value was obtained for the dose of 214 kg·N·ha^{-1} (Figure 1c), indicating a higher concentration of pigments on these fruits. This result is different from the commonly reported that N reduces the coloring of peach (Olienyk et al. 1997), nectarines (Daane et al. 1995) and apple fruits (Souza et al. 2013). Although the difference in fruit coloring is observed after application of different doses of nitrogen fertilization, it is difficult to separate the indirect effects of this nutrient, provided by shading of the fruits due to the greatest vegetative growth (Daane et al. 1995).

Regardless of the harvest season, pulp firmness (PF) of the fruits was not affected by nitrogen fertilization (Table 1), confirming the results found in other temperate fruit trees species (Daane et al. 1995; Ernani et al. 2008). In part, the lack of nitrogen fertilization response can be explained by the soil characteristics, similar to the observed for apple, for which the increase in nitrogen fertilization decreases the PF in Neosol, and when evaluated in Cambisol (same type of soil from this work), PF did not differ even with high doses of N (Souza et al. 2013). In addition, fertilizer application method can also influence the response. According Jia et al. (2006), peaches submitted to N as foliar application had reduction in fruit firmness, because leaf application decreases the effects of soil on the treatment.

Despite not having been found differences in PF, peach fruits from trees subjected to high doses of nitrogen fertilizer may be more susceptible to damage (mechanical, by pathogens and insects). In nectarine, even without changing the PF, N reduces the thickness of the cuticle favoring damage occurrence (Daane et al. 1995).

In spite of the difference observed in the third season for the evaluated chemical attributes (SS and SS/TA), these differences were not detectable by the evaluators in sensorial analysis (Figure 2). The parceling of nitrogen fertilization may have influenced the absence of differences in sensory attributes. According to Olienyk et al. (1997), the application of a single dose of N (45 kg·ha^{-1} at the start of sprouting) improved peach fruit flavor, however, when the same or twice the amount was divided, there was no effect on sensory attributes. Although N did not affect the sensory attributes of the fruit at harvest, future work should take into account its effect on the storage potential of the produced fruits. Pascual et al. (2013) observed that the N/Ca ratio in peach fruit is the variable that best correlates with the polyphenol oxidase enzyme (PPO), and the increase in the activity of this enzyme reduces the storage capacity.

CONCLUSION

The effect of the application of nitrogen fertilizer in the third consecutive harvest season resulted in increase in SS attributes, SS/TA ratio and 'Chimarrita' peach fruit epidermis color to the dose of 148 kg de N·ha^{-1}·year^{-1}.

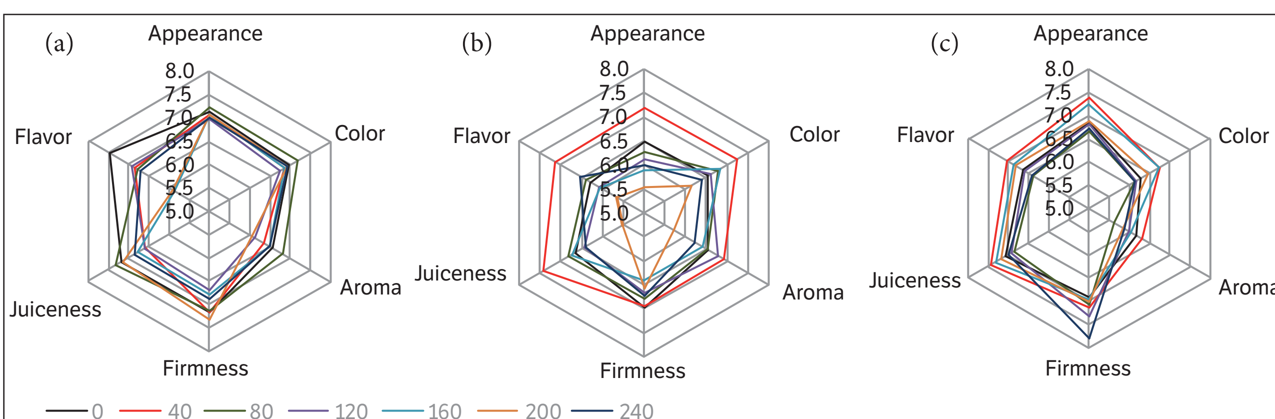

Figure 2. Average grade of the sensory attributes obtained by the acceptance test of 'Chimarrita' peach fruits (*Prunus persica*) to the following harvest seasons: (a) 2008/2009; (b) 2009/2010 and (c) 2010/2011, under nitrogen fertilization doses of N (kg·ha^{-1}·year^{-1}).

There is no difference between green pruning intensity and fruit quality of 'Chimarrita' peaches.

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