

Response of ‘Sensação’ peach trees to phosphate fertilization

Resposta de pessegueiros ‘Sensação’ à adubação fosfatada

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Abstract

Phosphorus is part of several organic compounds in plant metabolism such as nucleotides and phosphoproteins, in addition to participating in metabolism and energy storage. This study aimed to evaluate the response of peach trees cv. Sensação to phosphate fertilization and establish the critical level of this nutrient in soil and leaves. The experiment was conducted in the 2016 and 2017 cycles in a commercial orchard located in Morro Redondo, RS, Brazil. The experimental design was a randomized block design with four replications. Peach trees were fertilized with increasing doses of phosphorus (P) of 0, 20, 40, 60, and 80 kg ha⁻¹ of P₂O₅ as triple superphosphate. In the two evaluated cycles, samples of soil at a depth of 0–20 cm and leaves were collected to determine mineral contents. The data were submitted to analysis of variance by the F test (P<0.05), and when the effects were significant, regression equations were adjusted. P application increased the contents of this nutrient in the soil. Leaf P contents were not affected by fertilization, as well as productivity and yield components. Thus, the critical level of P in soil and peach leaves could not be established. In soils where P contents are classified as medium and high, there is no need to apply this nutrient.

Key words: Soil fertility. Phosphorus. Productivity. *Prunus persica*. Leaf content.

Resumo

O fósforo faz parte de numerosos compostos orgânicos no metabolismo das plantas, como nucleotídeos e fosfoproteínas além de participar do metabolismo e armazenamento de energia. O objetivo do presente trabalho foi avaliar a resposta de pessegueiros cv. Sensação a adubação fosfatada e estabelecer o nível crítico deste nutriente no solo e nas folhas. O experimento foi conduzido nos ciclos 2016 e 2017 em um pomar comercial localizado no município de Morro Redondo/RS – Brasil. O delineamento experimental foi de blocos ao acaso com quatro repetições. Os pessegueiros foram adubados com doses crescentes de fósforo (P), sendo estas, 0, 20, 40, 60 e 80 kg ha⁻¹ de P₂O₅ na forma de superfosfato triplo. Nos dois ciclos avaliados foram coletadas amostras de solo na camada de 0-20 cm e de folhas para determinação dos teores de minerais. Os dados obtidos, foram submetidos a análise de variância pelo teste F (P<0,05), e quando os efeitos foram significativos, ajustadas as equações de regressão. A aplicação de P aumentou os teores deste nutriente no solo. Os teores foliares de P não foram afetados pela adubação, bem como a produtividade e os componentes de rendimento. Sendo assim, não foi possível estabelecer um nível crítico de P no solo e nas folhas de pessegueiros. Em solos onde os teores de P são classificados como médios e acima disso, não há a necessidade de se aplicar este nutriente.

Palavras-chave: Fertilidade do solo. Fósforo. Produtividade. *Prunus persica*. Teor foliar.

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Introduction

In Brazil, peach crop is widespread in a great variety of soils from the state of Rio Grande do Sul to Minas Gerais. Rio Grande do Sul is the main Brazilian state in production and planted area of peach trees, standing out in the South region (IBGE, 2018). However, some factors, such as climate, soil, and infrastructure in rural areas have led the region of Pelotas to low productive rates of this fruit. This low productivity, when compared to other peach-producing regions in Brazil, leads to the need for researches to improve cultivation techniques, thus increasing orchard productivity and income of producers.

Diversity of soil and climate characteristics in the growing regions, together with the lack of application of methods for monitoring fertility conditions, often means that the practice of fertilization is done empirically or through agronomic speculation, i.e., without the use of soil or leaf analysis, leading the producer to carry out inadequate fertilizations (FREIRE; MAGNANI, 2014).

Nutritional requirements of fruit species at full production vary strongly depending on species and adopted rootstock, increasing significantly as a function of production volume (ROMBOLÁ et al., 2012). 'Capdeboscq' is widely used as a rootstock in southern Brazil due to its high germination capacity and fast development of seedlings in nursery stage (FINARDI, 1998); it originated from the cross between cv. Lake City and selection S-56-37, with an easy adaptation and high vigor (RASEIRA et al., 2014). 'Sensação' cultivar is originated from hybridization between cv. Alpes and selection Conserva 102; it is a dual-purpose cultivar, i.e., both for processing and for in natura consumption, requiring less than 300 hours of cold and with an excellent adaptation to the Pelotas region (RASEIRA et al., 2014).

Fertilization is one of the agricultural practices of significant importance, considered mandatory in most crops, consisting of the replacement of nutrients

required in higher quantity by plants. Among these nutrients are the nitrogen (N), potassium (K), and phosphorus (P). P is the nutrient among the macro-elements that has the third highest export rate through fruits and other plant organs (TAGLIAVINI et al., 2000).

In soil, P has a high affinity for pH, calcium, iron, aluminum, and clay, which may determine its availability. Thus, unlike other nutrients, phosphate fertilization has the peculiarity in which is applied larger amounts than that plants required since it is necessary to satisfy soil requirements, saturating the components responsible for phosphorus fixation (FURTINI NETO et al. al., 2001).

In this context, this study aimed to evaluate the response of peach trees 'Sensação' to phosphate fertilization and establish the critical level of phosphorus in soil and leaves.

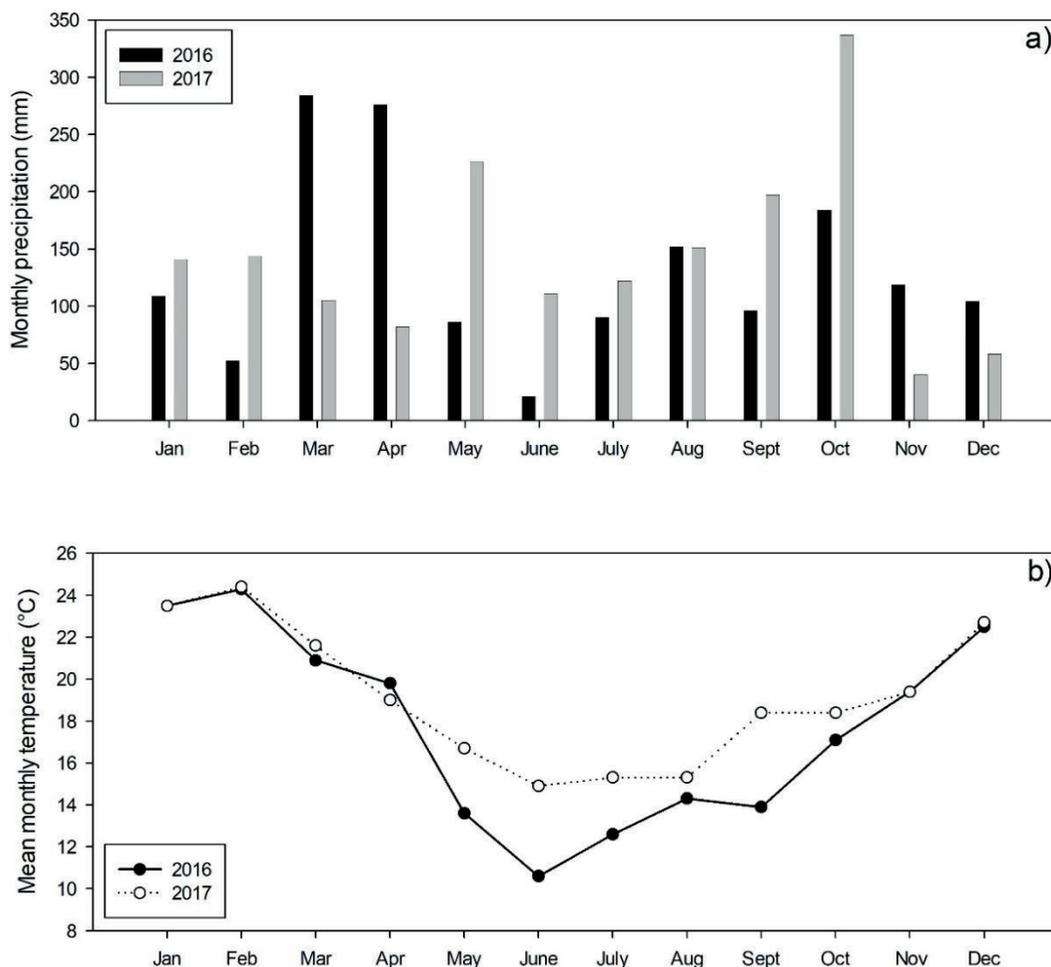
Material and Methods

This study was developed in a commercial orchard of peach trees cv. 'Sensação.' As informed by the owner of the orchard, seedlings were purchased from a commercial nursery owner who indicated the rootstock as being 'Capdeboscq.' The spacing was 5 meters between rows and 2 meters between plants, totaling 1000 plants per hectare implemented in 2009 and located in Morro Redondo, RS (31°31'49.3" S and 52°35'39.8" W). The experiment was established in 2016, and the 2016 and 2017 cycles were evaluated. According to Köppen, the regional climate is classified as Cfa with warm summers (ALVARES et al., 2013). The soil of the experimental area is classified as a Grayish Brown Argisol, moderate A graveling, and prominent medium/clay texture with a wavy to very wavy relief (EMBRAPA, 2006).

At the experiment locality, 348 and 198 hours of cold below 7.2 °C (AGROMET, 2018) were recorded in 2016 and 2017, respectively. Monthly precipitations and mean monthly temperatures

(Figure 1) were obtained from the Embrapa Temperate Agriculture automatic station (31°42' S and 52°24' W), located at Embrapa Temperate Agriculture headquarters. The orchard was managed with mowing in the interrow and desiccation with herbicides in the row.

Figure 1. Monthly precipitation in mm (a) and mean monthly temperatures in °C (b) at the experiment locality in the 2016 and 2017 cycles (AGROMET, 2018).



The experimental design was a randomized block design with four replications. Each experimental unit was composed of three plants, being the central plant considered as useful for evaluation purposes. Each block received increasing P doses of 0, 20, 40, 60, and 80 kg ha⁻¹ of P₂O₅ as triple superphosphate applied at full flowering, i.e., when 50% of the flowers were open in both evaluated cycles, totaling five plots with different doses applied to soil surface without incorporation. All plots received equal N

and K doses, as recommended by CQFS-RS/SC (2004).

The initial soil analysis in the 0–20 cm layer showed the following results: phosphorus of 36.1 mg dm⁻³, classified as high (CQFS-RS/SC, 2016); potassium of 160.1 mg dm⁻³; magnesium of 0.9 cmol_c dm⁻³; calcium of 3.7 cmol_c dm⁻³; clay of 17%; organic matter of 2.1%; effective CEC of 5.0; and SMP of 6.3.

During the two productive cycles, complete leaves (blade + petiole) were collected from the middle part of the branches of the year at the different quadrants of plants, between the 13th and 15th week after full flowering, being dried, ground, and prepared for analysis of the total P content (CQFS-RS/SC, 2004, 2016), according to the methodology proposed by Carmo et al. (2000). After harvest, according to CQFS-RS/SC (2004, 2016), the soil was collected in the 0–20 cm layer to determine the P content in both cycles, according to Tedesco et al. (1995). The following variables were evaluated to determine the production: number of fruits per plant; productivity (Mg ha^{-1}); mean weight of fruits (g) by weighing them in a digital scale, with results expressed in grams; fruit diameter (mm), performed with a digital caliper and results expressed in millimeters.

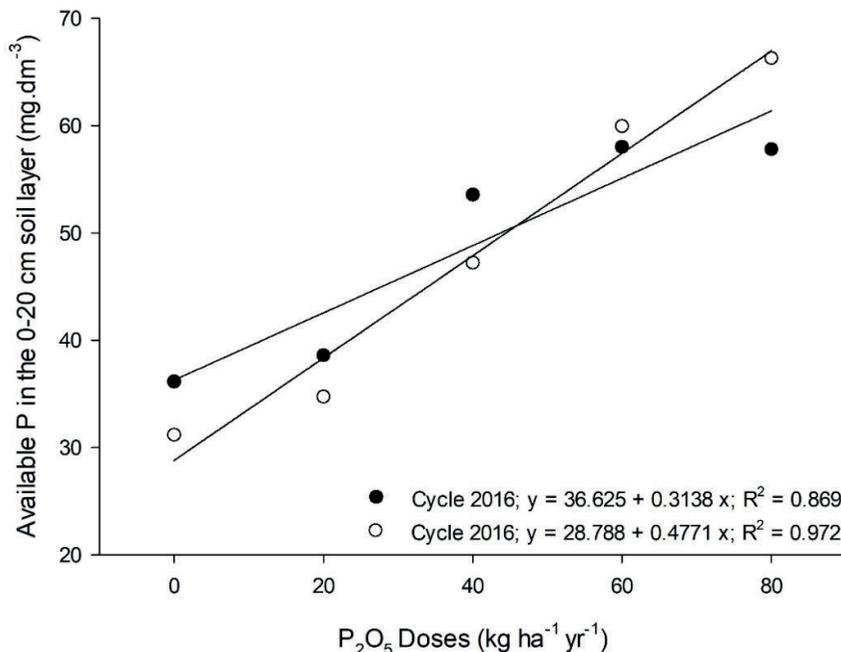
The results were submitted to analysis of variance by the F test ($P < 0.05$), and when the effects were significant, regression equations were adjusted. The results of soil and leaf analysis were correlated with each other, as well as with productivity.

Results and Discussion

The content of available P in the 0–20 cm layer was linearly increased as a function of the applied doses in the two cycles (Figure 2). This increase in P content in the soil surface layer corroborates the results of Nava et al. (2017) and Brunetto et al. (2015), who studied phosphate fertilization in apple and pear trees, respectively.

According to Brunetto et al. (2015), P tends to form an inner-sphere complex with functional groups of reactive soil particles, leading to a decrease in P mobility in the soil solution and its consequent deposition in more superficial layers. Also, P has a high affinity for iron oxides present in soil organic matter and can be adsorbed by cation bridges (RHEINHEIMER et al., 2008). Therefore, considering the accumulation of organic matter in the surface layer, P is concentrated more easily in this layer, which characterizes it as having low mobility in the soil profile.

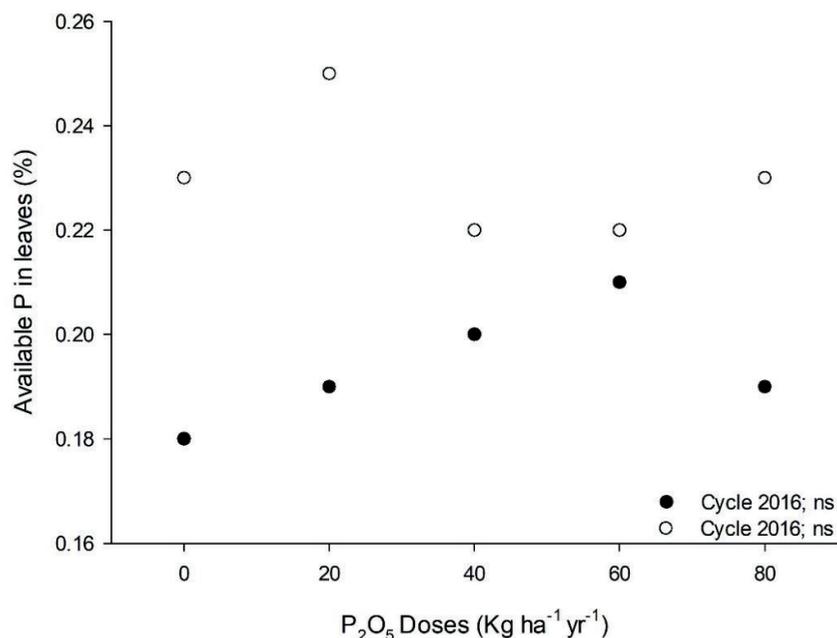
Figure 2. Available phosphorus content (Mehlich-1) in the soil of an orchard of ‘Sensação’ peach trees submitted to fertilization with different phosphorus doses in two consecutive cycles (mean of four replications).



Leaf P contents (Figure 3) did not show a response to phosphate fertilization in both cycles, with values in all treatments and cycles considered normal (0.15–0.30%) according to the classification

of CQFS-RS/SC (2016). These results indicate that the initial P contents in the leaves were enough to meet the requirements of peach plants.

Figure 3. Phosphorus content in leaves of 'Sensação' peach trees submitted to fertilization with different phosphorus doses in two consecutive cycles (mean of four replications).



In the 2016 cycle, only fruit diameter and mean weight of fruits showed significant differences between P doses, decreasing linearly (Table 1). The diameter has a proportional relationship with the mean weight of fruits, i.e., smaller fruits consequently have a lower weight. Possibly, the decrease in fruit diameter observed in the 2016 cycle with P increment is due to an increase in the number of fruits per plant, even with no significant difference between treatments. Thus, an inverse relationship between fruit diameter and the number of fruits could have occurred in plants, corroborating the data found by Giovanaz et al. (2016). Thus, a higher number of fruits means more drains and higher competition for photoassimilates, causing the plant to produce fruits with smaller diameters and, consequently, lower mean weight. However, even with a lower number of fruits, productivity was not affected, i.e., a lower number of fruits

with higher weight equates to a higher number of fruits with lower weight (Table 1). Considering that peach producers are remunerated mainly by fruit size, the non-application of P resulted in higher profitability in this cycle. According to Mathias et al. (2008), during fruit growth, weight gain and diameter increase are influenced by climate and management factors (thinning, fertilization, and irrigation). Considering the increase of the mean P contents in leaf tissue (Figure 3) and soil (Figure 2), P application increased the number of fruits per plant in this cycle, even visually. In the 2017 cycle, a lower number of fruits per plant and, consequently, a higher mean weight of fruits was obtained, which is possibly due to the lower number of hours of cold observed. It may also be related to the higher precipitation observed during the fruit growth period (Figure 1).

Table 1. Productivity, number of fruits per plant, fruit diameter, and mean weight of fruits of ‘Sensação’ peach trees submitted to fertilization with different phosphorus doses in two consecutive cycles (mean of four replications).

P ₂ O ₅ dose (kg ha ⁻¹)	Productivity (Mg ha ⁻¹)	Number of fruits per plant	Fruit diameter (mm)	Mean weight of fruits (g)
2016 cycle				
0	24.61	268.25	60.16	95.54
20	23.83	267.25	61.19	92.19
40	22.95	256.50	56.75	91.51
60	24.20	310.25	52.59	80.22
80	25.51	325.75	52.56	77.05
CV %	28.55	31.82	5.46	13.4
Linear	ns	ns	** ⁽¹⁾	* ⁽²⁾
Quadratic	ns	ns	ns	ns
2017 cycle				
0	22.79	200.50	64.09	116.39
20	24.13	224.75	63.04	107.33
40	21.93	206.25	59.84	110.35
60	20.27	161.00	64.28	126.18
80	18.89	160.00	64.60	117.40
CV %	19.01	25.16	6.22	21.08
Linear	ns	ns	ns	ns
Quadratic	ns	ns	ns	ns

^{ns} Non-significant for regression analysis; * significant at 5% probability; ** significant at 1% probability; ⁽¹⁾ $y = 63.79 - 2.38x$; $R^2 = 0.856$; ⁽²⁾ $y = 101.99 - 4.895x$; $R^2 = 0.905$.

In the 2017 cycle, productive attributes did not present significant differences between P doses (Table 1). In this cycle, the number of fruits per plant was lower in all treatments when compared to the 2016 cycle, resulting in higher means of fruit diameter and mean weight of fruits without productivity reduction.

In the fruit plants, thinning practice is indispensable to obtain an adequate production. Peach trees with high fruit loads lead to the production of small fruits with low commercial value, as well as the breaking of branches due to their weight (PEREIRA; RASEIRA, 2014; GIOVANAZ et al., 2016). It can also promote an alternation of production.

Nava et al. (2017) also observed the lack of response to phosphate fertilization in fruit

plants. These authors evaluated the productive characteristics of ‘Fuji’ apple trees submitted to different phosphorus doses for five consecutive cycles and observed no differences in productivity and other productive attributes. Brunetto et al. (2015) also observed no response in ‘Rocha’ pear trees to phosphate fertilization for three evaluation cycles.

In this experiment, the lack of response of P occurs because this nutrient is applied to the surface without incorporation and has low mobility in the soil. Moreover, the initial soil P content was 36.1 mg dm⁻³. According to Mayer et al. (2007), thinner and younger roots of peach trees, responsible for a large part of water and nutrient absorption, are found in deeper soil layers. Thus, the surface application may not have increased P contents near the area

of root absorption, not affecting the productive characteristics of plants. Also, there is a contribution of organic phosphorus (Po), which may constitute 5–80% of soil P (RHEINHEIMER; ANGHINONI, 2003). Po is originated from the plant residues added to the soil, microbial tissue, and products of its decomposition (RHEINHEIMER et al., 2000; CONTE et al., 2002; 2003; MARTINAZZO et al., 2007).

No response of fruit yield was observed as a function of phosphate fertilization, with no possibility to establish the critical P level the peach crop between leaf (Figure 4) and soil P contents (Figure 5). Similar responses were obtained in other crops, such as apple (NAVA et al., 2017) and pear (BRUNETTO et al., 2015), in which their critical P level could not be established due to lack of response to the application of different P doses.

The low response may be due to the initial P levels in the soil because of the low export of this nutrient by fruits, i.e., P reserves in the soil and plant possibly supply the requirements of plants. According to Ernani et al. (2000), the low response

to phosphate fertilization may be attributed to the perennial characteristic, which allows a longer period of soil nutrient absorption. Another factor that reduces the response of fruit trees to phosphate fertilization is the association of roots with hyphae of arbuscular mycorrhizal fungi (JEFFRIES et al., 2003), which increases the explored soil volume, maximizing nutrient absorption, mainly P (MIRANSARI, 2010).

The rootstock also influences nutrient absorption. However, according to Mayer et al. (2015), the 'Capdeboscq' rootstock showed no differences in leaf content of peach trees compared to other rootstocks. Also, the extensive use of this rootstock in the region is attributed to its high seed germination capacity and its fast development in the nursery (FINARDI, 1998). Reighard et al. (2013) tested 24 *Prunus* rootstocks and observed differences in leaf P content, but not so low as to impair fruit quality. Jimenes et al. (2018) tested 14 *Prunus* rootstocks in nectarine trees and observed differences between leaf P contents in different rootstocks, but all the results were within the adequate leaf P levels.

Figure 4. Relationship between relative yield (%) and leaf phosphorus content (%) of 'Sensação' peach trees submitted to fertilization with different phosphorus doses in two consecutive cycles (mean of four replications).

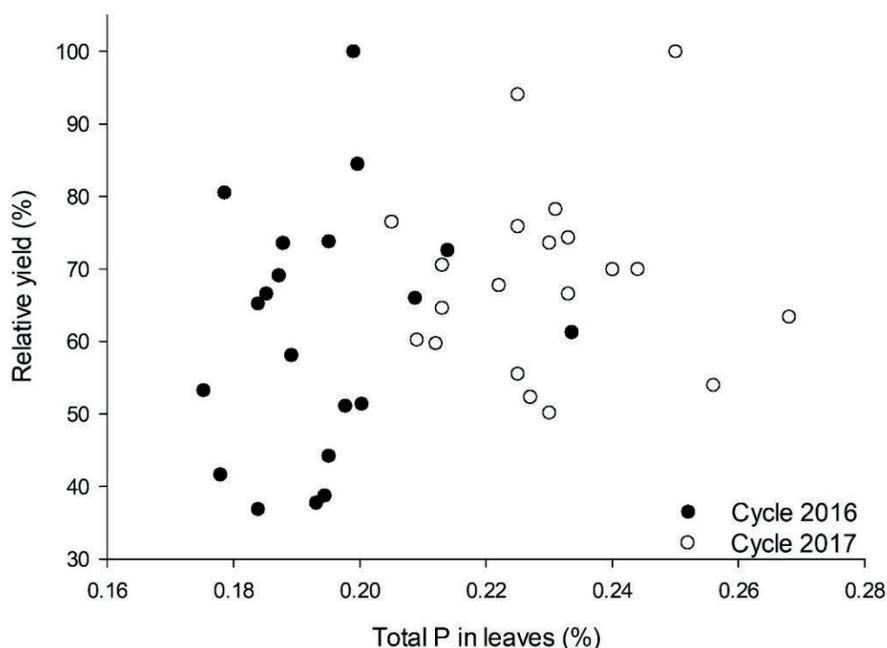
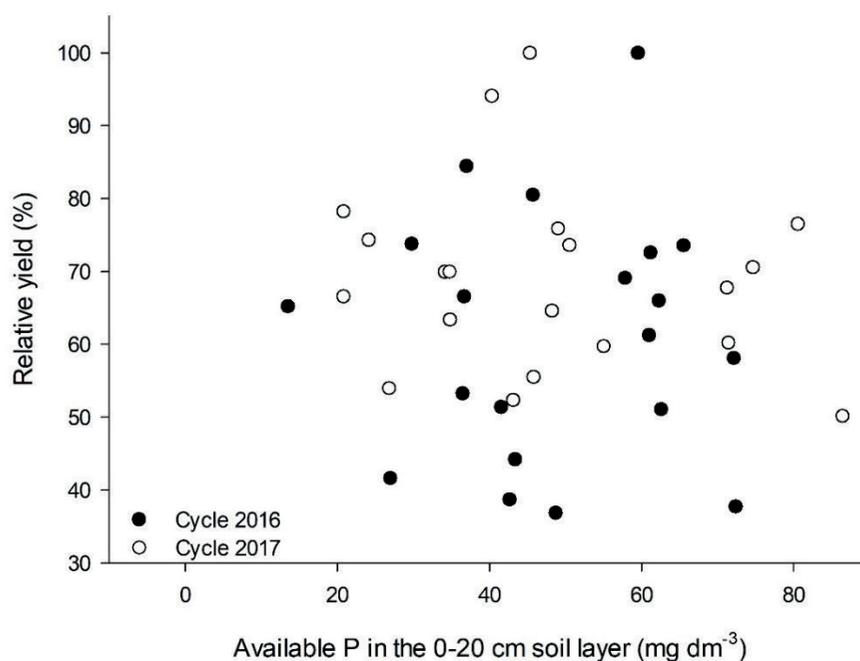


Figure 5. Relationship between the relative yield of ‘Sensação’ peach trees and the available P content (Mehlich-1) in the 0–20 cm soil layer in two consecutive cycles (mean of four replications).



Conclusions

Phosphorus application increased the levels of this nutrient in the 0–20 cm soil layer.

Leaf phosphorus content did not respond to the application of this nutrient in the soil.

Production and yield components of plants did not respond to the surface phosphorus application. Thus, in soils where P content in the 0–20 cm layer is considered high, with no need for its application.

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