Evaluation of Soil Management and Use in an Ultisol in a Guava Orchard in Comparison with a Sugarcane Field and Native Forest Area

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Abstract

Studies to find out alternative inputs are important for sustainable agriculture. In this respect, the use of byproducts from guava processing can partially replace the requirements of mineral fertilizer and add organic matter to the soil, increased water retention capacity and mitigating the effects of traffic on the soil. The aim of the present study was to assess the physical aspects of the soil in function of fertilization of guava trees with organic and mineral fertilizers and to compare the results with those found in areas of sugarcane and native forest. The soil samples were obtained from a commercial guava orchard planted with the ‘Paluma’ (8 years) and ‘Pedro Sato’ (5 years) cultivars, vegetatively propagated, as well as from a cane field (5 years) and native forest for comparison. The results revealed that the soil moisture, density and penetration resistance varied between the different uses and fertilization regimes. The volumetric moisture and density in the areas cultivated with ‘Paluma’ guava trees were similar to those of the native forest. The soil moisture was greater in the rows of the guava trees and the density and penetration resistance were greater in the traffic paths.

INTRODUCTION

The addition of organic material to the soil can help improve water retention and mitigate the effects of movement of equipment over the soil. These effects are different for each type of soil use and management practices. According to Mundt et al. (2012), organic fertilization affects both the physical and chemical characteristics of the soil, increasing the cation exchange capacity and availability of nutrients to the plants, while at the same time affecting the soil density and porosity.

Among the physical attributes of soil, density can particularly affect plant yields because it influences the storage of water and penetration of the roots.

The use of organic byproducts, either of residential or industrial origin, in agricultural areas can be justified by the need to find alternatives to the disposal of these materials in landfills or open dumps because of the increasing generation of waste by a growing population. In this sense, recycling can ease the burden placed on other forms of disposal.

The soil management practices adopted have a major influence on the ecological aspects of farming from a conservationist perspective in comparison with natural vegetation or other crops that are grown in a determined region. The use of organic residues as sources of nutrients and soil conditioners can enhance yields while at the same
time reducing the need for disposal of these materials.

The aim of this study was to assess the physical attributes of the soil under different management practices and uses, specifically a guava orchard, sugarcane field and native forest area.

MATERIAL AND METHODS

The guava orchard studied was located on a commercial farm of eight years of age for the ‘Paluma’ cultivar and five years for the ‘Pedro Sato’. The trees were propagated vegetatively. The orchard was irrigated by revolving microsprayers (31 L per hour), monitored by tensiometr (60%) (CC), with the water provided by a semi-artesian well. The trees were spaced at 5 m apart in rows 7 m apart, the standard for these cultivars. The experimental area located in the municipality of Vista Alegre do Alto (21°08’S latitude; 48°30’W longitude, altitude 603 m), in the main guava producing region of the state of São Paulo.

The orchard’s soil was classified as Ultisol, or Red-Yellow Argisol (Embrapa, 1999). The initial fertility results of the chemical analysis were: 5.3, 11, 8, I, 2.7, 18, 6, 16, 26.7, 42.7, 0.0 and 63, respectively, for pH (CaCl₂), O.M. (g dm⁻³), Pr resin and S-SO₄²⁻ (mg dm⁻³), K, Ca, Mg, H⁺Al, SB, T, Al (mmolc dm⁻³) and V (%).

The industrial byproduct employed in this study consisted basically of ground seeds together with a small fraction of the skin and pulp not separated during the pulping process, carried out after washing the fruits. The chemical contents were estimated according to the method described by Bataglia et al. (1983), which shows the following results: 4.7, 11.6, 1,749, 18.7, 290, 2.1, 2.3, 0.8, 0.9, 1.3, 10, 15, 12, 28 and 25, respectively, for pH; N_total (g kg⁻¹), N-NH₄⁺, N-NO₃⁻ (mg kg⁻¹), C_organic, P, K, Ca, Mg, S (g kg⁻¹), B, Cu, Fe, Mn, Zn (mg kg⁻¹) and C/N. The byproduct was applied once in each year from 2006 to 2010 at the beginning in the year.

The experimental design was randomized blocks, in subdivided plots, with six treatments, two sampling positions and four repetitions. The treatments (plots) were GS (organic fertilization with 18 t ha⁻¹ of dried and ground guava seed material – dry basis (65°C by 72h) – of the ‘Paluma’ cultivar); MFPA (mineral fertilization according to the technical recommendation (Natale et al., 1996) for the ‘Paluma’ cultivar); FS (organic fertilization with 18 t ha⁻¹ of fresh seed material – dry base – of the ‘Paluma’ cultivar); MFPS (mineral fertilization according to the technical recommendation (Natale et al., 1996) for the ‘Pedro Sato’ cultivar); SC (sugarcane, cultivar ‘RB86-7515’, with age of 5 years of cultivation, grown in an area adjacent to the guava orchard, with mineral fertilization and mechanical harvesting); and NF (a native seasonal semi-deciduous forest area for reference in a preserved portion of the Atlantic Forest). The sampling positions (sub-plots) were R (row of the crops) and T (agricultural machinery traffic paths). The doses of the byproduct applied in the orchard were established in function of the nitrogen content (independent of whether the seeds were dried and ground or fresh, in both cases considered on a dry basis).

The mass-volume ratio measurements (gravimetric moisture, volumetric moisture and soil density) were carried only out in January 2012 by gathering undeformed samples from the top soil layer (0-0.20 m), utilizing the method proposed by Embrapa (1997), employing rings measuring 53.70 cm³ (4.77 cm in diameter × 3.00 cm in height). The soil mechanical penetration resistance (MPR) was measured with a Falkor model PL5200 automatic penetrometer, with precision of 10 mm, equipped with a type 3 cone, with an angle of 45°, which presents a maximum cone index of 15,100 KPa and works at a nominal insertion speed of 35 mm s⁻¹.

The data were stored in the device’s memory and then transferred to a computer by cable hookup and use of the Penetrolog software (Falker, 2009).

The results were submitted to analysis of variance, and when significant, the Tukey test (5%) was employed, with the aid of the SISVMFPA statistical program (Ferreira, 2008), as well as calculation of the Pearson correlation coefficient between the variables studied.
RESULTS AND DISCUSSION

There were significant differences in the soil moisture content at the time of sampling. The gravimetric moisture values (Ug) were higher in the native forest area (NF) than in the orchard that received 18 t ha⁻¹ of the seed byproduct, both in ground form (GS) and fresh form (FS). The other environments with different soil uses and management types presented similar gravimetric moisture values to that of the native forest (Table 1).

According to the data on volumetric moisture (θ), the areas cultivated with sugarcane (SC) and ‘Pedro Sato’ guava trees provided with mineral fertilizer (MFPS) higher values than those observed for the GS, AM and NF groups. The FS treatment presented lower volumetric moisture than the soil from the orchard planted with ‘Paluma’ trees given only mineral fertilization (MFPA) (Table 1).

The volumetric moisture values have a significant inverse linear relationship with the soil density, as shown in Figure 1a (R=−0.81), since the increase in density leaves less space to be occupied by water for the same volume. The Ds levels confirm this behavior, since the MFPS and SC treatments, which had lower volumetric moisture values, also presented higher density values. In these treatments, the values were higher than those obtained in the forest and MFPA plot. The value for the soil in the orchard area planted with ‘Pedro Sato’ trees given mineral fertilization (higher Ds value) exceeded that obtained with application of 18 t ha⁻¹ of ground seed material on the ‘Paluma’ cultivar. The soil density behavior can be explained by the fact the ‘Pedro Sato’ trees were younger (5 years) than the ‘Paluma’ ones (8 years), meaning less deposition of plant mass due to pruning. Another possible explanation is the effect of mineral fertilization along with the addition of the ground organic byproduct. Besides this, the intensity of the passage of machines and workers is different between the types of trees, especially during the harvest period. The ‘Paluma’ fruits, allocated for industrial processing, are only harvested when they are ripe, once or twice a week, while the ‘Pedro Sato’ fruits, sold to be eaten fresh, are harvested three or more time a week, intensifying the traffic of machines and workers. This fact, associated with the lower influx of organic material, can explain the higher soil density observed. The values observed in these treatments (GS, FS and MFPS) were similar to that found in the sugarcane field. Although the structures of guava trees and sugarcane are different, it is possible that the concern over the soil compacting caused by the passage of machines in the cane field can also be relevant for fruit orchards, since soil compaction can reduce the uptake of water and nutrients from the soil and impair productivity.

According to Alfonsi (2010), approximately 50% of rainwater does not penetrate the soil, which can affect crop growing cycles. In the case of sugarcane, the factor most affected by soil compaction is root growth, which is restricted. Mundt et al. (2012) found a reduced yield of ‘Paluma’ trees with increased soil density, and that the application of organic fertilizer increased the soil porosity. While Souza et al. (2011) observed that the application of a ground byproduct from guava processing improved some soil chemical attributes.

The traffic of machines in the same position year after year results in significant compacting of the soil in comparison with the samples obtained from the tree rows (Table 1). This effect was observed in all the treatments except in the cane field, where there was greater penetration resistance in the row of the plants and correlation.

ACKNOWLEDGEMENTS

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Literature Cited


Tables

Table 1. Means, F-value and coefficient of variation in the different cultures and positions regarding gravimetric moisture (Ug), volumetric moisture (θ), density (Ds) and mechanical penetration resistance (MPR).

<table>
<thead>
<tr>
<th>Factors</th>
<th>Ug (g H2O g⁻¹ dry soil)</th>
<th>θ (m³ m⁻³)</th>
<th>Ds (kg m⁻³)</th>
<th>MPR (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paluma 18 Mg ground seeds (GS)</td>
<td>0.080 b</td>
<td>0.3314 ab</td>
<td>1601.8 bc</td>
<td>1923.56 ab</td>
</tr>
<tr>
<td>Paluma mineral recommendation (MRP)</td>
<td>0.091 ab</td>
<td>0.3410 a</td>
<td>1549.0 c</td>
<td>2082.50 ab</td>
</tr>
<tr>
<td>Paluma 18 Mg fresh seeds (FS)</td>
<td>0.079 b</td>
<td>0.3056 bc</td>
<td>1614.8 abc</td>
<td>2513.01 b</td>
</tr>
<tr>
<td>Pedro Sato mineral recommendation (MRPS)</td>
<td>0.097 ab</td>
<td>0.2783 c</td>
<td>1710.5 a</td>
<td>1987.22 ab</td>
</tr>
<tr>
<td>Sugarcane (SC)</td>
<td>0.094 ab</td>
<td>0.2790 c</td>
<td>1684.2 ab</td>
<td>2203.53 ab</td>
</tr>
<tr>
<td>Native forest (NF)</td>
<td>0.105 a</td>
<td>0.3498 a</td>
<td>1564.8 c</td>
<td>1601.42 a</td>
</tr>
<tr>
<td>F</td>
<td>3.83*</td>
<td>23.17**</td>
<td>8.31**</td>
<td>0.0001**</td>
</tr>
<tr>
<td>CV</td>
<td>15.9</td>
<td>5.8</td>
<td>3.9</td>
<td>21.60</td>
</tr>
</tbody>
</table>

Positions

<table>
<thead>
<tr>
<th>Factor</th>
<th>F</th>
<th>CV</th>
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<tbody>
<tr>
<td>Row</td>
<td>0.32m</td>
<td>8.47**</td>
</tr>
<tr>
<td>Traffic path</td>
<td>18.2</td>
<td>13.9</td>
</tr>
<tr>
<td>Interaction</td>
<td>1.55m</td>
<td>1.59m</td>
</tr>
</tbody>
</table>

ns, *, **: not significant and significant at 5 and 1% by the Tukey test, respectively.
Fig. 1. Correlations between the soil density (Ds) and mechanical penetration resistance (MPR) in a dystrophic Ultisol in the municipality of Vista Alegre do Alto, São Paulo, in 2012. Mean of 4 repetitions. R²=coefficient of determination; CV=coefficient of variation; ** - significant at 5%.