Chlorophyll index for real-time prediction of nutritional status of ‘Prata’ banana

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Key words: Musa spp. cultivars nutrients chlorophyll

A B S T R A C T
This study aimed to select regression equations based on the correlation between chlorophyll index and leaf nutrient contents, for real-time prediction of the nutritional status of ‘Prata’ banana. Six cultivars of ‘Prata’ banana were used as treatments, with five replicates and four plants per plot, arranged in a completely randomized design. Nutrient levels were evaluated based on laboratorial analysis and chlorophyll indices using a portable chlorophyll meter, in the third leaf from the apex to the base. Data were subjected to analysis of variance, calculating the correlations between leaf nutrient contents and chlorophyll indices, and the regression equations were adjusted to the associations that were significant and with greater magnitude. The selected models estimate leaf nutrient contents and allow a real-time, low-cost reliable prediction of the nutritional status of ‘Prata’ banana. It is an auxiliary technique that, combined with leaf and soil analysis, contributes to a more precise and secure nutritional evaluation.

Palavras-chave: Musa spp. cultivares nutrientes clorofila

Índice de clorofila para predição do estado nutricional de bananeiras tipo Prata em tempo real

R E S U M O
Objetivou-se, com o presente trabalho, selecionar equações de regressão com base na correlação entre o índice de clorofila e os teores foliares de nutrientes para predição em tempo real do estado nutricional de bananeiras tipo Prata. Utilizaram-se, como tratamentos, seis cultivares de bananeira tipo Prata com cinco repetições e quatro plantas úteis por parcela, dispostas em delineamento experimental inteiramente casualizado. Avaliaram-se os teores de nutrientes com base em análises laboratoriais e os índices de clorofila com um medidor portátil na terceira folha do ápice para a base. Os dados foram submetidos à análise de variância; calcularam-se as correlações entre teores foliares de nutrientes e índices de clorofila e se ajustaram equações de regressões para as associações significativas e com maior magnitude. Os modelos selecionados estimam os teores foliares de nutrientes e permitem predizer com segurança em tempo real e a baixo custo, o estado nutricional de bananeiras tipo Prata. Constitui uma técnica auxiliar que, aliada à diagnose foliar e à análise de solos, contribui para uma avaliação nutricional mais criteriosa e segura.
Introduction

Banana plants are highly demanding in nutrients, especially potassium and nitrogen, which makes fertilization the most costly production factor and the one that influences the amount and quality of the production, as the resistance to diseases.

Nutritional evaluation is essential for the recommendation of fertilization for the crop. Leaf tissue analysis, combined with soil chemical analysis and visual diagnosis, reflects the dynamics of nutrients in the soil-plant system (Donato et al., 2010).

The joint use of these techniques allows increasing the precision of the diagnosis, but the reliability of the results depends on the sampling process and the technical knowledge of the evaluator. The costs and the delay in obtaining the results hamper the decision-making process, which may represent losses in production and quality.

The use of indirect measurements to determine the demand for nutrients has been studied, especially due to its speed, easy determination and low cost. Real-time information supporting the evaluation of nutritional status of banana is essential for the decision-making process in production systems that have increasingly demanded production precision and security (Fontes, 2011).

The existence of correlation between chlorophyll leaf contents determined in the laboratory through spectrophotometer or indirect chlorophyll meters and plant growth characteristics, as well as leaf nutrient contents, especially N, has been shown in experiments with different crops (Reis et al., 2006; Godoy et al., 2008; Ribeiro et al., 2009; Backes et al., 2010; Pôrto et al., 2011; Haim et al., 2012).

However, studies of this nature are lacking for the banana crop (Melô et al., 2014). Chlorophyll content can be estimated from its correlation with a dimensionless value generated by the chlorophyll meter, which measures the green color intensity, based on values calculated by the differential reading of the amount of light transmitted by the leaf in two wavelength regions: 650 nm, at which light is absorbed by chlorophyll and 940 nm, at which light is not absorbed (Swiader & Moore, 2002).

The correlation between the chlorophyll index and the leaf contents of nutrients allows the adjustment of models to predict the nutritional status of the banana crop. In addition, it is easily measured and non-destructive.

This study aimed to adjust regression equations based on the correlation between the chlorophyll index, estimated using a chlorophyll meter, and leaf nutrient contents determined in the laboratory, to provide a real-time prediction of the nutritional status of ‘Prata’ banana.

Material and Methods

The experiment was carried out from 2010 to 2012 in a Red Yellow Latosol at the Federal Institute of Bahia, Campus of Guanambi, with mean annual rainfall and temperature of 680 mm and 26 °C, respectively.

Samples of the soil used for the installation of the banana orchard, from the layers of 0-20 cm and 21-40 cm, were sent to the Laboratory of Soils of the Northern Minas Gerais Regional Unit of EPAMIG (Agricultural Research Company of Minas Gerais) and their chemical properties are shown in Table 1.

Soil samples from the layer of 0-20 cm were collected at the end of the second production cycle in all the plots and the contents of nutrients are shown in Table 2.

Micropropagated seedlings were planted (May 11, 2010) at the spacing of 3.0 x 2.5 m, totaling 1,333 plants per hectare. Implantation and cultural practices followed the recommendations for the crop (Rodrigues et al., 2008).

At planting and every two months, during both production cycles, organic fertilizations were performed using 36 L of cattle manure, which correspond to 13.68 kg per cluster of plants, with the following composition: organic matter content = 63.73 g kg⁻¹; moisture at 65 °C = 16.72%; pH = 7.42; density = 0.38 g cm⁻³; macronutrients (N, P, K, Ca, Mg and S) = 5.2, 4.7, 2.5, 1.7, 0.2 and 2.3 g kg⁻¹, respectively and micronutrients (B, Cu, Zn, Mn and Fe) = 2.1, 45.2, 200.5, 391.8 and 1,932.4 mg kg⁻¹, respectively.

Four months after planting and during the flowering of each cycle, 25 g of Mg and 30 g of K₂O per cluster of plants were applied broadcast, using magnesium sulfate and potassium chloride. Applications of B and Zn were performed in the rhizome (Rodrigues et al., 2007; Nomura et al., 2011), of the thinned seedling, every four months, with 1.7 g of B, as boric acid, and 4 g of Zn per cluster of plants, as zinc sulfate.

Sprinkler irrigation was performed using Netafim® pressure-compensating emitters, with flow rate of 120 L h⁻¹, radius of throw of 7.4 m, a red nozzle of 1.57 mm, spaced by 6 m between lateral lines and 5 m between emitters.

The water used in the experiment came from a tubular well and is classified as C3S1 – water with high salinity and low sodium concentration, with the following chemical characteristics: pH = 6.6, Electrical conductivity = 0.82 dS m⁻¹.

Table 1. Chemical characteristics of two composite soil samples, from the layers of 0-20 and 21-40 cm, collected in the experimental area.

<table>
<thead>
<tr>
<th>Char.</th>
<th>Unit</th>
<th>0-20 cm</th>
<th>Standard deviation</th>
<th>21-40 cm</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (H₂O)</td>
<td>mg dm⁻³</td>
<td>7.60</td>
<td>0.14</td>
<td>7.60</td>
<td>0.57</td>
</tr>
<tr>
<td>P</td>
<td>Na⁺</td>
<td>318.15</td>
<td>157.47</td>
<td>185.80</td>
<td>21.78</td>
</tr>
<tr>
<td>K</td>
<td>cmol dm⁻³</td>
<td>567.50</td>
<td>45.96</td>
<td>512.50</td>
<td>154.86</td>
</tr>
<tr>
<td>Na⁺</td>
<td>cmol dm⁻³</td>
<td>0.20</td>
<td>0.00</td>
<td>0.15</td>
<td>0.07</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>cmol dm⁻³</td>
<td>3.45</td>
<td>0.49</td>
<td>2.90</td>
<td>0.00</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>cmol dm⁻³</td>
<td>1.70</td>
<td>0.28</td>
<td>1.30</td>
<td>0.00</td>
</tr>
<tr>
<td>Al³⁺</td>
<td>cmol dm⁻³</td>
<td>0.00</td>
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<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>H⁺ + Al³⁺</td>
<td>cmol dm⁻³</td>
<td>0.90</td>
<td>0.00</td>
<td>0.95</td>
<td>0.07</td>
</tr>
<tr>
<td>S.B.</td>
<td>cmol dm⁻³</td>
<td>6.75</td>
<td>0.92</td>
<td>5.65</td>
<td>0.35</td>
</tr>
<tr>
<td>T²⁺</td>
<td>cmol dm⁻³</td>
<td>6.75</td>
<td>0.92</td>
<td>5.65</td>
<td>0.35</td>
</tr>
<tr>
<td>T⁺</td>
<td>cmol dm⁻³</td>
<td>6.75</td>
<td>0.92</td>
<td>6.65</td>
<td>0.21</td>
</tr>
<tr>
<td>V⁴⁻</td>
<td>%</td>
<td>88.00</td>
<td>1.41</td>
<td>85.00</td>
<td>1.41</td>
</tr>
<tr>
<td>m³⁻</td>
<td>%</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>O.M.⁺</td>
<td>dag dm⁻³</td>
<td>1.35</td>
<td>0.21</td>
<td>1.00</td>
<td>0.14</td>
</tr>
<tr>
<td>B</td>
<td>mg dm⁻³</td>
<td>0.85</td>
<td>0.07</td>
<td>0.75</td>
<td>0.07</td>
</tr>
<tr>
<td>Cu⁺⁺</td>
<td>mg dm⁻³</td>
<td>1.05</td>
<td>0.21</td>
<td>0.85</td>
<td>0.21</td>
</tr>
<tr>
<td>Fe³⁺</td>
<td>mg dm⁻³</td>
<td>11.85</td>
<td>2.33</td>
<td>11.35</td>
<td>3.46</td>
</tr>
<tr>
<td>Mn⁺⁺</td>
<td>mg dm⁻³</td>
<td>47.95</td>
<td>3.75</td>
<td>40.70</td>
<td>11.60</td>
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<tr>
<td>Zn⁺⁺</td>
<td>mg dm⁻³</td>
<td>24.25</td>
<td>4.31</td>
<td>13.30</td>
<td>2.40</td>
</tr>
<tr>
<td>P-rem³⁻</td>
<td>Mg L⁻¹</td>
<td>42.16</td>
<td>0.92</td>
<td>41.40</td>
<td>3.68</td>
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<tr>
<td>EC⁰</td>
<td>dS m⁻¹</td>
<td>1.70</td>
<td>0.00</td>
<td>1.95</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Char.: Characteristics; Sum of bases; Effective cation exchange capacity (effective CEC); CEC at pH 7.0; Base saturation; Aluminium saturation; Organic matter; Remaining phosphorus; Electrical conductivity; pH in water; OM: Colorimetry; P, K, Na, Cu, Fe, Mn and Zn – Mehlich-1 Extractor; Ca, Mg and Al – 1 mol L⁻¹ KCl Extractor; H + Al: pH SMP; B – Hot water
Table 2. Mean values of soil chemical characteristics in the layer of 0-20 cm, in area cultivated with different ‘Prata’ banana cultivars, after two production cycles

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Unit</th>
<th>Maravilha</th>
<th>BRS FHIA-18</th>
<th>FHIA-18</th>
<th>BRS Platina</th>
<th>Prata-Anã</th>
<th>JV42-135</th>
<th>Mean</th>
<th>CV (%)</th>
</tr>
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<tr>
<td>pH</td>
<td>-</td>
<td>7.53</td>
<td>7.59</td>
<td>7.44</td>
<td>7.47</td>
<td>7.53</td>
<td>7.63</td>
<td>7.35</td>
<td>2.16</td>
</tr>
<tr>
<td>OM</td>
<td>mg kg⁻¹</td>
<td>2.32</td>
<td>1.16</td>
<td>2.63</td>
<td>1.89</td>
<td>2.03</td>
<td>2.34</td>
<td>2.07</td>
<td>3.0</td>
</tr>
<tr>
<td>P</td>
<td>mg dm⁻³</td>
<td>412.21</td>
<td>342.67</td>
<td>388.74</td>
<td>343.73</td>
<td>362.89</td>
<td>399.3</td>
<td>374.92</td>
<td>20.16</td>
</tr>
<tr>
<td>K</td>
<td>mg dm⁻³</td>
<td>278.71</td>
<td>313.71</td>
<td>328.43</td>
<td>272.86</td>
<td>283.14</td>
<td>308.14</td>
<td>297.17</td>
<td>51.48</td>
</tr>
<tr>
<td>Na</td>
<td>cmol dm⁻³</td>
<td>0.23</td>
<td>0.26</td>
<td>0.24</td>
<td>0.26</td>
<td>0.26</td>
<td>0.24</td>
<td>0.25</td>
<td>35.62</td>
</tr>
<tr>
<td>Ca</td>
<td>cmol dm⁻³</td>
<td>4.56</td>
<td>4.43</td>
<td>4.79</td>
<td>4.59</td>
<td>4.89</td>
<td>5.04</td>
<td>4.78</td>
<td>12.69</td>
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<td>Mg</td>
<td>cmol dm⁻³</td>
<td>2.76</td>
<td>2.56</td>
<td>2.67</td>
<td>2.76</td>
<td>2.93</td>
<td>2.97</td>
<td>2.81</td>
<td>20.99</td>
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<td>H₂A⁵⁺</td>
<td>cmol dm⁻³</td>
<td>0.79</td>
<td>0.81</td>
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<td>0.8</td>
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<td>0.79</td>
<td>0.79</td>
<td>12.93</td>
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<tr>
<td>SB</td>
<td>cmol dm⁻³</td>
<td>8.69</td>
<td>8.04</td>
<td>8.73</td>
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<td>8.79</td>
<td>9.01</td>
<td>8.59</td>
<td>10.44</td>
</tr>
<tr>
<td>t</td>
<td>cmol dm⁻³</td>
<td>8.69</td>
<td>8.04</td>
<td>8.73</td>
<td>8.29</td>
<td>8.79</td>
<td>9.01</td>
<td>8.59</td>
<td>10.44</td>
</tr>
<tr>
<td>T</td>
<td>cmol dm⁻³</td>
<td>9.46</td>
<td>8.86</td>
<td>9.5</td>
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<td>9.49</td>
<td>9.77</td>
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<td>9.15</td>
</tr>
<tr>
<td>V</td>
<td>-</td>
<td>91.57</td>
<td>91</td>
<td>91.57</td>
<td>91.24</td>
<td>91.71</td>
<td>91.5</td>
<td>91.5</td>
<td>1.65</td>
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<tr>
<td>B⁶</td>
<td>mg dm⁻³</td>
<td>5.26</td>
<td>0.97</td>
<td>1.1</td>
<td>1.23</td>
<td>1.29</td>
<td>1.01</td>
<td>1.81</td>
<td>254.47</td>
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<tr>
<td>Cu</td>
<td>mg dm⁻³</td>
<td>1.7</td>
<td>1.91</td>
<td>2.14</td>
<td>1.54</td>
<td>1.57</td>
<td>1.43</td>
<td>1.72</td>
<td>32.36</td>
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<tr>
<td>Fe</td>
<td>mg dm⁻³</td>
<td>13.37</td>
<td>18.24</td>
<td>21.37</td>
<td>24.03</td>
<td>24.06</td>
<td>21.3</td>
<td>21.4</td>
<td>25.27</td>
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<tr>
<td>Mn</td>
<td>mg dm⁻³</td>
<td>71.17</td>
<td>68.83</td>
<td>71.84</td>
<td>67.59</td>
<td>65.23</td>
<td>68.63</td>
<td>68.88</td>
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<tr>
<td>Zn</td>
<td>mg dm⁻³</td>
<td>35.37a</td>
<td>30.80ab</td>
<td>32.51ab</td>
<td>26.61b</td>
<td>28.87ab</td>
<td>33.47ab</td>
<td>31.27</td>
<td>14.32</td>
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<tr>
<td>P-rem⁷</td>
<td>mg L⁻¹</td>
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<td>42.27</td>
<td>42.13</td>
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<td>41.64</td>
<td>42.01</td>
<td>41.86</td>
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</tr>
<tr>
<td>EC</td>
<td>dS m⁻¹</td>
<td>1.44</td>
<td>1.54</td>
<td>1.54</td>
<td>1.47</td>
<td>1.39</td>
<td>1.4</td>
<td>1.47</td>
<td>23.12</td>
</tr>
</tbody>
</table>

¹pH in water; ²Colorimetry; ³Extractor: Mehlich-1; ⁴Extractor: 1 mol L⁻¹ KCl; ⁵pH-SMP method; ⁶Extractor: BaCl₂; ⁷Extractor: Ca(H₂PO₄)₂, 500 mg L⁻¹ of P in 2 mol L⁻¹ HOAc; ⁸pH equilibrium solution of P; SB (sum of bases); t (effective CEC); T (CEC at pH 7.0); V (base saturation); m (aluminum saturation); P-rem (remaining phosphorus); EC (electrical conductivity) dag/kg = %; mg dm⁻³ = ppm; cmol dm⁻³ = meq 100 cm⁻³. Means followed by the same letter do not differ by Tukey test at 0.05 probability level

Results and Discussion

The mean contents of nutrients in the leaves of ‘Maravilha’, ‘BRS Platina’, ‘FHIA-18’, ‘BRS FHIA-18’, ‘Prata-Anã’ and ‘JV42-135’ followed the following decreasing order: K > N > Ca > Mg > S > P (Table 3). The contents of N, P, K and S were higher than and the contents of Ca and Mg were similar to those observed by Borges et al. (2006).

Table 3. Leaf contents of nutrients and chlorophyll of ‘Prata’ banana cultivars in two production cycles

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Unit</th>
<th>Maravilha</th>
<th>BRS FHIA-18</th>
<th>FHIA-18</th>
<th>BRS Platina</th>
<th>Prata-Anã</th>
<th>JV42-135</th>
<th>Mean</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>g kg⁻¹</td>
<td>30.00</td>
<td>30.50</td>
<td>30.60</td>
<td>30.29</td>
<td>30.60</td>
<td>31.70</td>
<td>31.05</td>
<td>10.20</td>
</tr>
<tr>
<td>P</td>
<td>g kg⁻¹</td>
<td>2.00</td>
<td>2.00</td>
<td>2.20</td>
<td>2.10</td>
<td>2.00</td>
<td>2.00</td>
<td>2.05</td>
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<tr>
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<td>36.80</td>
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<td>37.50</td>
<td>37.08</td>
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<td>2.60</td>
<td>2.40</td>
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<td>2.80</td>
<td>2.53</td>
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<td>4.03</td>
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<td>7.54</td>
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<td>164.21</td>
<td>124.16</td>
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<td>112.25</td>
<td>86.94</td>
<td>99.09</td>
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<tr>
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<td>g kg⁻¹</td>
<td>36.99</td>
<td>43.39</td>
<td>29.19</td>
<td>35.50</td>
<td>40.24</td>
<td>50.85</td>
<td>39.36</td>
<td>39.83</td>
</tr>
<tr>
<td>Ch1</td>
<td>g kg⁻¹</td>
<td>34.97</td>
<td>36.81</td>
<td>36.19</td>
<td>37.76</td>
<td>36.87</td>
<td>35.73</td>
<td>36.39</td>
<td>4.18</td>
</tr>
<tr>
<td>Ch2</td>
<td>g kg⁻¹</td>
<td>15.66</td>
<td>17.89</td>
<td>16.65</td>
<td>18.14</td>
<td>17.14</td>
<td>15.71</td>
<td>16.87</td>
<td>10.89</td>
</tr>
<tr>
<td>Ch</td>
<td>g kg⁻¹</td>
<td>50.63</td>
<td>54.70</td>
<td>52.85</td>
<td>55.99</td>
<td>54.01</td>
<td>51.44</td>
<td>53.26</td>
<td>6.11</td>
</tr>
</tbody>
</table>

¹Chlorophyll a; ²Chlorophyll b; ³Total chlorophyll
Nutritional status evaluations of irrigated banana orchards in Northern Minas Gerais, conducted by Silva & Rodrigues (2001), showed the following decreasing orders of percentage of samples deficient in macronutrients: K = S > P > N > Mg > Ca and in micronutrients Zn > Cu > Fe > Mn > B.

K is the nutrient absorbed in highest amounts by the plant; in addition, its high contents in the soil, in the layers of 0-20 and 21-40 cm, respectively, may have influenced its lower absorption and lower leaf contents.

All the cultivars showed leaf contents of macronutrients above the sufficiency range (g kg\(^{-1}\)) determined for 'Prata-Anã' bananas (Silva & Borges, 2008): N (25.00-29.00); P (1.50-1.90); K (27.00-35.00); S (1.70-2.00); Ca (4.50-7.50) and Mg (2.40-4.00), except for K in 'FHIA 18' (34.70 g kg\(^{-1}\)) and Ca in 'Maravilha' (7.40 g kg\(^{-1}\)) and in 'BRS Platina' (6.60 g kg\(^{-1}\)), which remained within the range (Table 3).

The leaf contents of macronutrients in the banana cultivars did not differ by Tukey test at 0.05 probability level (Table 3). Silva et al. (2007) also observed no differences between the leaf contents of nutrients of 99 'Prata-Anã' banana orchards, with three yield levels. These authors justified that other involved factors determined the yield. Contents above the ideal range, for all the cultivars, are related to the availability of nutrients in the soil and to the continuous translocation between the mother plant and the daughter plants, and vice versa.

The leaf contents of micronutrients in 'Prata' banana cultivars did not differ by Tukey test (p > 0.05) (Table 3), which is not consistent with Borges et al. (2006), who observed differences in the contents of 24 cultivars of different subgroups.

The leaf contents of most micronutrients and sodium were within the ideal range for 'Prata-Anã', determined by Silva & Borges (2008): B (12-25 mg kg\(^{-1}\)); Cu (2.6-8.8 mg kg\(^{-1}\)); Fe (72-157 mg kg\(^{-1}\)); Mn (173-630 mg kg\(^{-1}\)); Zn (14-25 mg kg\(^{-1}\)) and (20-60 mg kg\(^{-1}\)), respectively. There was a reduction of B contents in 'FHIA-18', 'BRS Platina' and 'JV42-135', Cu contents in 'FHIA-18' and Fe contents in 'JV42-135', for which the values remained above the range. Deficiency was observed for Mn in all the cultivars, and the values remained below the sufficiency range. The high leaf contents of micronutrients can be explained by the high contents in the soil, caused by the large supply of fertilizers characterizing the history of the area, besides irrigation.

Banana plants are usually deficient in the micronutrients B and Zn. Low leaf contents of Zn are common in the Northern region of Minas Gerais, associated with high Zn contents in the soil, which indicates restriction in its availability to plants (Rodrigues et al., 2007), probably due to the high pH, also caused by the irrigation water.

Banana trees extract small amounts of Cu, which is not much used in fertilization programs, due to the rare occurrence of deficiency symptoms, despite the reports of Silva & Rodrigues (2001) for Northern Minas Gerais. Higher pH conditions and large supply of organic matter reduce the availability of this nutrient.

Despite the great variation observed in leaf Na content (74.2%), also reported for the Northern region of Minas Gerais (Silva & Rodrigues, 2001), especially due to climatic conditions and irrigation water, the values obtained in the present study remained below the toxic level described in the literature.

Chlorophyll indices estimated by the device did not differ between cultivars by Tukey test (p > 0.05) (Table 3). Although there are differences in the efficiency of absorption of nutrients between these cultivars (Silva et al., 2014), under conditions of high fertility (Table 1), with increase in the availability of nutrients promoted by irrigation and fertilization, the high contents characterize conditions of luxury consumption, especially for K, the element with highest cycling rate in the banana orchard.

Besides higher soil fertility, variations in crop management and climatic conditions may justify the differences in leaf contents and yields recorded in the present study (Table 4) for 'Prata-Anã', 'Maravilha' and 'BRS FHIA-18', in comparison to the results of Borges et al. (2006).

The yields observed in both cycles for the evaluated cultivars in the present study (Table 4) were high and are consistent with the results obtained by Donato et al. (2009) in similar conditions. The obtained yields, in t ha\(^{-1}\), for mass of hands were: 37.80 and 67.80 ('BRS FHIA-18'), 32.10 and 49.90 ('FHIA-18'), 31.90 and 47.40 ('Maravilha'), 25.40 and 43.10 ('BRS Platina') and 21.30 and 34.20 t ha\(^{-1}\) ('Prata-Anã') in the first and second cycle, respectively.

The mass of hands and bunches, in both the first (33.72 kg) and the second (39.40 kg) cycle, were higher for the cultivar 'Maravilha' (Table 4). For both variables, in the first cycle, 'BRS Platina' and 'FHIA-18' showed intermediate values. 'Prata-Anã' was similar to 'BRS FHIA-18' and 'JV42-135', which did not differ from 'BRS Platina' and 'FHIA-18'. In the second cycle, 'Prata-Anã', 'BRS Platina' and 'JV42-135' showed the lowest values and 'FHIA-18' and 'BRS FHIA-18' showed intermediate values.

In the first cycle, the period from planting to harvest was 442.6 days for 'FHIA-18' and 440.7 days for 'JV42-135', a cycle longer than that of 'Maravilha' and 'BRS FHIA-18', with 385.70 and 390.66 days, respectively (Table 4); in the second cycle, the period was 670.1 days for 'Maravilha' and 513.30 days for 'BRS FHIA-18'.

For all the cultivars, the correlations were significant (p < 0.10), positive and with high magnitude, between the leaf contents of at least two nutrients and the chlorophyll indices. Exceptions occurred for 'Maravilha', which showed negative associations between leaf K contents and chlorophyll b indices (-0.88) and between leaf Cu contents and chlorophyll a indices (-0.81) (Table 5). Also, for 'FHIA-18' between Ca contents and chlorophylls a and b, as well as for Cu contents and chlorophyll b, and for 'JV42-135', between leaf K contents and chlorophyll b and total.

Negative correlations with high magnitude between the leaf contents and chlorophyll indices were also observed in the cultivars 'JV42-135', 'FHIA-18' and 'Prata-Anã'. For 'JV42-135', the negative associations occurred between leaf K contents
and the indices of chlorophyll b (-0.97) and total (-0.86). For ‘FHIA-18’, negative associations occurred between leaf Ca contents and the indices of chlorophyll a and b (-0.95 and -0.87, respectively) and between leaf Cu contents and chlorophyll b (-0.87); for ‘Prata-Anã’, between the leaf Na contents and the indices of chlorophyll a, b and total: -0.90, -0.81 and -0.86, respectively (Table 5).

The leaf contents of Mg and N showed the highest number of significant, positive correlations of high magnitude with the chlorophyll indices, for all the cultivars. This is justified by the fact that both participate in the chlorophyll molecule and perform functions related to photosynthesis (Marschner, 2012).

Melo et al. (2014) also observed positive correlation between the chlorophyll content and N content in leaves of ‘Prata-Anã’ banana.

As to the micronutrients, leaf B content showed the highest number of significant, positive associations of high magnitude with the chlorophyll indices, because its functions are related to N metabolism. B deficiency reduces the use of light absorbed in the photosystems, induces the oxidation of phenolic compounds, hampers antioxidant defense mechanisms of plants and increases their susceptibility to the high intensity of light and the generation of reactive oxygen species, which would explain the direct relationship between B contents and CI (Marschner, 2012).

For ‘Maravilha’, the correlations with high magnitude, positive and more significant (p < 0.05) occurred between the leaf contents of N and Mg and the index of chlorophyll b (0.96 and 0.95, respectively), between S contents and total chlorophyll (0.91) and between the contents of B and Zn and the index of chlorophyll a (0.91 and 0.92, respectively) (Table 5).

For ‘BRS FHIA-18’, there were positive correlations, with high magnitude and significance (p < 0.05) between leaf N contents and the indices of chlorophyll a (0.98) and total (0.97), between leaf S contents and chlorophyll a (0.90) and between leaf Zn contents and chlorophyll a (0.91) (Table 5).

For the cultivar ‘FHIA-18’, there was high and significant correlation at 0.05 probability level only between Mg contents and chlorophyll b (0.90), direct correlation, and between Ca and chlorophyll a (-0.95), inverse correlation. The high direct correlation observed between Cu and chlorophyll b was significant at 0.10 probability level; however, positive associations with high magnitude were observed for ‘BRS Platina’ (p < 0.10) between leaf Ca contents and the index of chlorophyll a (0.81) and between the leaf Mg contents and chlorophyll b (0.85) (Table 5).

Table 5. Phenotypical correlations between leaf contents of nutrients and the indices of chlorophyll a, b and total, with the respective tests of significance, in ‘Prata’ banana cultivars

<table>
<thead>
<tr>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Ca</th>
<th>Mg</th>
<th>B</th>
<th>Cu</th>
<th>Fe</th>
<th>Mn</th>
<th>Zn</th>
<th>Na</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorophyll</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chl-a</td>
<td>0.17</td>
<td>-0.02</td>
<td>-0.05</td>
<td>0.73</td>
<td>-0.00</td>
<td>0.08</td>
<td>0.91*</td>
<td>-0.81**</td>
<td>-0.37</td>
<td>0.85**</td>
<td>0.92*</td>
</tr>
<tr>
<td>Chl-b</td>
<td>0.96**</td>
<td>0.81**</td>
<td>-0.86**</td>
<td>0.81**</td>
<td>-0.46</td>
<td>0.95*</td>
<td>0.62</td>
<td>-0.14</td>
<td>0.82**</td>
<td>0.42</td>
<td>0.19</td>
</tr>
<tr>
<td>Chl-total</td>
<td>0.85**</td>
<td>0.67</td>
<td>-0.74</td>
<td>0.91*</td>
<td>-0.38</td>
<td>0.82**</td>
<td>0.81**</td>
<td>-0.38</td>
<td>0.82**</td>
<td>0.62</td>
<td>0.45</td>
</tr>
<tr>
<td>Chl-a</td>
<td>0.98*</td>
<td>0.79</td>
<td>0.32</td>
<td>0.90*</td>
<td>0.36</td>
<td>0.82**</td>
<td>0.61</td>
<td>0.75</td>
<td>0.79</td>
<td>0.69</td>
<td>0.91*</td>
</tr>
<tr>
<td>Chl-b</td>
<td>0.86**</td>
<td>0.39</td>
<td>-0.28</td>
<td>0.60</td>
<td>0.41</td>
<td>0.61</td>
<td>0.28</td>
<td>0.57</td>
<td>0.65</td>
<td>0.62</td>
<td>0.59</td>
</tr>
<tr>
<td>Chl-total</td>
<td>0.97*</td>
<td>0.60</td>
<td>-0.02</td>
<td>0.77</td>
<td>0.41</td>
<td>0.74</td>
<td>0.45</td>
<td>0.68</td>
<td>0.75</td>
<td>0.69</td>
<td>0.76</td>
</tr>
<tr>
<td>Chl-a</td>
<td>0.50</td>
<td>0.31</td>
<td>0.18</td>
<td>0.34</td>
<td>-0.95*</td>
<td>-0.70</td>
<td>-0.02</td>
<td>-0.24</td>
<td>0.05</td>
<td>0.24</td>
<td>0.53</td>
</tr>
<tr>
<td>Chl-b</td>
<td>0.48</td>
<td>0.08</td>
<td>-0.32</td>
<td>0.28</td>
<td>-0.87*</td>
<td>0.90*</td>
<td>-0.03</td>
<td>-0.87**</td>
<td>0.01</td>
<td>0.14</td>
<td>-0.21</td>
</tr>
<tr>
<td>Chl-total</td>
<td>0.53</td>
<td>0.22</td>
<td>-0.05</td>
<td>0.34</td>
<td>-1.0</td>
<td>0.86**</td>
<td>-0.02</td>
<td>-0.57</td>
<td>0.03</td>
<td>-0.07</td>
<td>0.21</td>
</tr>
<tr>
<td>Chl-a</td>
<td>0.61</td>
<td>0.55</td>
<td>0.52</td>
<td>0.58</td>
<td>0.81**</td>
<td>0.67</td>
<td>0.68</td>
<td>0.55</td>
<td>0.57</td>
<td>0.64</td>
<td>0.55</td>
</tr>
<tr>
<td>Chl-b</td>
<td>0.74</td>
<td>0.70</td>
<td>0.71</td>
<td>0.67</td>
<td>0.65</td>
<td>0.85**</td>
<td>0.57</td>
<td>0.52</td>
<td>0.66</td>
<td>0.5</td>
<td>0.47</td>
</tr>
<tr>
<td>Chl-total</td>
<td>0.69</td>
<td>0.64</td>
<td>0.62</td>
<td>0.63</td>
<td>0.73</td>
<td>0.77</td>
<td>0.62</td>
<td>0.53</td>
<td>0.62</td>
<td>0.618</td>
<td>0.51</td>
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<tr>
<td>Chl-a</td>
<td>0.93*</td>
<td>0.65</td>
<td>-0.08</td>
<td>0.80**</td>
<td>0.62</td>
<td>0.89*</td>
<td>0.96*</td>
<td>-0.23</td>
<td>0.77</td>
<td>0.94*</td>
<td>0.69</td>
</tr>
<tr>
<td>Chl-b</td>
<td>0.80</td>
<td>0.83**</td>
<td>0.14</td>
<td>0.64</td>
<td>0.59</td>
<td>0.74</td>
<td>0.98*</td>
<td>-0.16</td>
<td>0.80</td>
<td>0.97*</td>
<td>0.84**</td>
</tr>
<tr>
<td>Chl-total</td>
<td>0.86**</td>
<td>0.76</td>
<td>0.05</td>
<td>0.71</td>
<td>0.60</td>
<td>0.81**</td>
<td>0.98*</td>
<td>-0.19</td>
<td>0.80</td>
<td>0.97*</td>
<td>0.76</td>
</tr>
<tr>
<td>Chl-a</td>
<td>0.74</td>
<td>0.67</td>
<td>-0.60</td>
<td>-0.76</td>
<td>0.63</td>
<td>0.85**</td>
<td>0.42</td>
<td>-0.50</td>
<td>0.58</td>
<td>0.75</td>
<td>0.35</td>
</tr>
<tr>
<td>Chl-b</td>
<td>0.82**</td>
<td>0.60</td>
<td>-0.97*</td>
<td>-0.27</td>
<td>0.83**</td>
<td>0.83**</td>
<td>0.88*</td>
<td>-0.03</td>
<td>0.83**</td>
<td>1.0</td>
<td>0.86**</td>
</tr>
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<td>Chl-total</td>
<td>0.85**</td>
<td>0.67</td>
<td>-0.86</td>
<td>-0.50</td>
<td>0.79</td>
<td>0.89*</td>
<td>0.73</td>
<td>-0.24</td>
<td>0.77</td>
<td>0.95*</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Table 4. Agronomic characteristics of ‘Prata’ banana cultivars in two production cycles

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Cycle</th>
<th>Maravilha</th>
<th>BRS FHIA-18</th>
<th>FHIA-18</th>
<th>BRS Platina</th>
<th>Prata-Anã</th>
<th>JYV42-135</th>
<th>Mean</th>
<th>CV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of hands (kg)</td>
<td>1&lt;sup&gt;o&lt;/sup&gt;</td>
<td>33.72 A</td>
<td>20.86 BC</td>
<td>24.02 B</td>
<td>21.36 B</td>
<td>15.58 C</td>
<td>20.47 BC</td>
<td>22.67</td>
<td>12.04</td>
</tr>
<tr>
<td>Mass of bunches (kg)</td>
<td>2&lt;sup&gt;o&lt;/sup&gt;</td>
<td>39.40 A</td>
<td>27.34 B</td>
<td>30.07 B</td>
<td>21.34 C</td>
<td>19.55 C</td>
<td>19.90 C</td>
<td>26.27</td>
<td>11.11</td>
</tr>
<tr>
<td>Period until harvest (days)</td>
<td>1&lt;sup&gt;o&lt;/sup&gt;</td>
<td>363.70 B</td>
<td>390.66 B</td>
<td>442.6 A</td>
<td>399.45 AB</td>
<td>426.00 AB</td>
<td>440.71 A</td>
<td>414.19</td>
<td>5.4</td>
</tr>
<tr>
<td>Yield in mass of hands (t ha&lt;sup&gt;-1&lt;/sup&gt; year&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>-</td>
<td>52.36</td>
<td>45.06</td>
<td>44.07</td>
<td>36.92</td>
<td>30.37</td>
<td>31.62</td>
<td>40.07</td>
<td>-</td>
</tr>
<tr>
<td>Yield in mass of bunches (t ha&lt;sup&gt;-1&lt;/sup&gt; year&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>-</td>
<td>58.27</td>
<td>50.40</td>
<td>50.47</td>
<td>42.00</td>
<td>34.59</td>
<td>35.81</td>
<td>45.26</td>
<td>-</td>
</tr>
</tbody>
</table>

Means followed by the same letters in the row do not differ statistically by Tukey test at 0.05 probability level.
For 'Prata-Anã', direct correlations with high magnitude and significant (p < 0.05) were observed between the leaf contents of N and Mg and the index of chlorophyll a (0.93 and 0.89, respectively). The B contents in this cultivar stood out for the high degree of direct association with all the chlorophylls (a, b and total) (0.96, 0.98 and 0.98, respectively), as well as Mn and chlorophyll b (0.94, 0.97 and 0.97, respectively).

Mn is essential in the synthesis of photosynthetic pigments and acts in the activation of enzymes involved in the secondary metabolism. Its deficiency decreases the concentration of chlorophyll, drastically alters the ultrastructure of thylakoids and reduces photosynthesis and the photosynthetic evolution of O₂ in the photosystem II (Marschner, 2012). Direct and significant (p < 0.1) associations with high magnitude occurred between P contents and chlorophyll b (0.83), between S contents and chlorophyll a (0.80) and between Zn and chlorophyll b (0.84).

For 'Maravilha', a linear model was adjusted, which estimates an increase of 1.18 g kg⁻¹ in leaf N content for each unit variation in Chl-b. The model estimates leaf N content within the sufficiency range in the Chl-b interval of 11.44-14.81 (Table 6). The second adjusted model predicts the Mg content within the sufficiency range when the values of Chl-b are in the interval of 11.17-15.66 and predicts an increase of 0.035 g kg⁻¹ of Mg for each unit variation in Chl-b.

Models predicting the contents of B and Zn were also adjusted for this cultivar. For B, the model predicts an increase of 12.30 mg kg⁻¹ for each unit variation in CI and also predicts leaf B contents within the adequate range in the Chl-a interval of 34.05-35.27. For Zn, the model estimates an increase of 4.48 mg kg⁻¹ for each unit variation in CI and predicts leaf contents within the sufficiency range in the Chl-a interval of 34.50-36.96.

The models selected for the prediction of N and Zn contents in 'BRS FHIA-18', based on Chl-a and total, estimate increases of 1.75 g kg⁻¹ and 2.82 g kg⁻¹ in leaf contents, respectively, for each unit increase in Chl-a and Zn contents. The models were used to estimate the leaf contents of nutrients within the sufficiency range for 'Prata-Anã', selected for all the cultivars.

Table 6 shows the regression models and the optimal intervals of chlorophyll indices (CI), which estimate the leaf contents of nutrients within the sufficiency range determined for 'Prata-Anã', selected for all the cultivars.

For 'Maravilha', a linear model was adjusted, which estimates an increase of 1.18 g kg⁻¹ in leaf N content for each unit variation in Chl-b. The model estimates leaf N content within the sufficiency range in the Chl-b interval of 11.44-14.81 (Table 6). The second adjusted model predicts the Mg content within the sufficiency range when the values of Chl-b are in the interval of 11.17-15.66 and predicts an increase of 0.035 g kg⁻¹ of Mg for each unit variation in Chl-b.

Models predicting the contents of B and Zn were also adjusted for this cultivar. For B, the model predicts an increase of 12.30 mg kg⁻¹ for each unit variation in CI and also predicts leaf B contents within the adequate range in the Chl-a interval of 34.05-35.27. For Zn, the model estimates an increase of 4.48 mg kg⁻¹ for each unit variation in CI and predicts leaf contents within the sufficiency range in the Chl-a interval of 34.50-36.96.

The models selected for the prediction of N and Zn contents in 'BRS FHIA-18', based on Chl-a and total, estimate increases of 1.75 g kg⁻¹ and 2.82 g kg⁻¹ in leaf contents, respectively, for each unit increase in Chl-a and Zn contents. The models were used to estimate the leaf contents of nutrients within the sufficiency range for 'Prata-Anã', selected for all the cultivars.

Table 6. Prediction equations for the leaf nutrient contents of 'Prata' banana cultivars as a function of the chlorophyll index (CI) generated by the Falker® Clorofilog CFL1030

<table>
<thead>
<tr>
<th>Dependent variable (leaf content)</th>
<th>Independent variable (CI)</th>
<th>Simple regression equation</th>
<th>Coefficient of determination (R²)</th>
<th>Optimal CI interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maravilha</td>
<td>N</td>
<td>N = 11.4064 + 1.1872 Chl b**</td>
<td>0.92</td>
<td>11.44-14.81</td>
</tr>
<tr>
<td></td>
<td>Mg</td>
<td>Mg = -1.59053 + 0.03569 Chl b**</td>
<td>0.90</td>
<td>11.57-15.66</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>B = -406.99 + 12.3041 Chl a**</td>
<td>0.82</td>
<td>34.05-35.27</td>
</tr>
<tr>
<td></td>
<td>Zn</td>
<td>Zn = -140.719 + 4.48339 Chl a**</td>
<td>0.84</td>
<td>34.50-36.96</td>
</tr>
<tr>
<td>BRS FHIA-18</td>
<td>N</td>
<td>N = -34.1489 + 1.75493 Chl a*</td>
<td>0.97</td>
<td>33.70-35.98</td>
</tr>
<tr>
<td></td>
<td>Zn</td>
<td>Zn = -84.9383 + 2.82298 Chl a**</td>
<td>0.84</td>
<td>35.03-38.93</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>N = -12.8190 + 0.79102 Chl Total**</td>
<td>0.94</td>
<td>47.81-52.86</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>Mn = 26971.1 - 1020.87 Chl Total** + 9.66049 Chl Total**</td>
<td>0.99</td>
<td>57.05-60.71 (1.05 (52.84))</td>
</tr>
<tr>
<td>FHIA-18</td>
<td>K</td>
<td>K = -116.943 + 5.67732 Chl Total** - 0.05084 Chl Total**</td>
<td>0.99</td>
<td>38.91-44.48 (41.55 (55.83))</td>
</tr>
<tr>
<td></td>
<td>Mg</td>
<td>Mg = -8.86616 + 0.812552 Chl b**</td>
<td>0.82</td>
<td>13.86-15.83</td>
</tr>
<tr>
<td></td>
<td>Mg</td>
<td>Mg = -15.3985 + 0.379820 Chl Total**</td>
<td>0.75</td>
<td>46.86-51.07</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>B = -45.5858 + 3.95454 Chl b*</td>
<td>0.96</td>
<td>14.05-17.84</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>Mn = -323.451 + 24.6873 Chl b**</td>
<td>0.94</td>
<td>20.11-38.62</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>N = -5.54102 + 0.669216 Chl Total***</td>
<td>0.74</td>
<td>45.63-51.61</td>
</tr>
<tr>
<td></td>
<td>Mg</td>
<td>Mg = -3.00141 + 0.092198 Chl a*</td>
<td>0.78</td>
<td>58.56-75.93</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>B = -104.031 + 2.33731 Chl Total**</td>
<td>0.96</td>
<td>48.76-55.20</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>Mn = -685.783 + 14.5444 Chl Total**</td>
<td>0.93</td>
<td>59.04-90.46</td>
</tr>
<tr>
<td></td>
<td>Zn</td>
<td>Zn = 3167.44 - 119.165 Chl Total** + 1.12603 Chl Total 2**</td>
<td>0.99</td>
<td>53.48-56.09 (13.65 (52.92))</td>
</tr>
<tr>
<td>JY42-135</td>
<td>Mg</td>
<td>Mg = -15.5538 + 0.3840055 Chl Total**</td>
<td>0.79</td>
<td>47.24-51.45</td>
</tr>
<tr>
<td></td>
<td>Mn</td>
<td>Mn = -1070.17 + 22.8633 Chl Total**</td>
<td>0.90</td>
<td>54.37-74.36</td>
</tr>
</tbody>
</table>

*Significant at 0.01 probability level (p < 0.01), **Significant at 0.05 probability level (p < 0.05), ***Significant at 0.10 probability level (p < 0.1) by t-test, *Maximum or minimum point for the quadratic models and the correspondent CI
equal to 52.84 and the leaf contents within the sufficiency range for the Chl-total interval of 57.05-60.71.

For ‘FHIA-18’, the model predicts the highest K content (41.55 g kg⁻¹) for Chl-total of 55.83 and contents within the sufficiency range in the interval of 38.91-44.48.

The models adjusted for ‘BRS Platina’ estimated Mg contents within the sufficiency range as a function of Chl-b and total, in the intervals of 13.86-15.83 and 46.96-51.07, respectively (Table 6). The models estimated increases of 0.81 g kg⁻¹ and 0.38 mg kg⁻¹ of Mg for each unit variation in Chl-b and Chl-total, respectively.

The models selected for ‘Prata-Anã’ considered the nutrients that commonly cause deficiency symptoms at the field. Linear models were selected as a function of Chlorophyll b, which estimate the leaf contents of B and Mn within the sufficiency range, in the Chl-b intervals of 14.05-17.84 and 20.11-38.62, respectively (Table 6). The models predict increases of 3.95 mg kg⁻¹ and 24.68 mg kg⁻¹ for B and Mn, respectively, for each unit variation in Chl-b.

Models related to total chlorophyll were also selected, which predict the leaf contents of N, B and Mn within the sufficiency range, in Chl-total intervals of 45.63-51.61, 48.78-55.20 and 59.04-90.46, respectively, which estimate increases of 0.67 g kg⁻¹, 2.34 mg kg⁻¹ and 14.54 mg kg⁻¹, for N, B and Mn respectively, for each unit variation in Chl-total. The quadratic model, as a function of Total chlorophyll, predicts the highest leaf content of Zn, 13.65 g kg⁻¹, for Chl-total of 52.92, and leaf contents within the sufficiency range in the interval of 53.48-56.09.

Estimates of leaf Mg contents for the cultivar ‘Prata-Anã’ were performed using the model adjusted as a function of Chl-a, which predicts an increment of 0.092 g kg⁻¹ for each unit variation in Chl-a. The mathematical model estimates the content of Mg within the sufficiency range in the Chl-a interval of 58.58-75.93.

A model that estimates leaf P contents was also adjusted for ‘Prata-Anã’. P is the third nutrient that most causes deficiency symptoms at the field, although with low application response (Silva & Rodrigues, 2013). The model based on the indices of chlorophyll a and b (P = 0.9975458 + 0.038125 Chl b + 0.039292 Chl a) was not shown in Table 6, because it demands calculations for obtaining P contents, which makes its use difficult, but does not invalidate it.

For ‘JV42-135’, the models estimate the contents of Mg and Mn within the optimal range, as a function of Chl-total in the intervals of 47.24-51.45 and 54.37-74.36, respectively, and also estimate increases of 0.38 g kg⁻¹ and 22.86 mg kg⁻¹ in the leaf contents of Mg and Mn, respectively, for each unit variation in Chl-total.

The optimal CI intervals determined through regression models can serve as a basis for the inference on the nutritional status of banana orchards in real time, in a practical, fast and inexpensive way. The technique requires no calculation and consists in the comparison between the values obtained with the device and the intervals (Table 6).

**Conclusions**

1. The adjusted models are able to provide a real-time, reliable prediction of the nutritional status of ‘Prata’ bananas, in an easy, fast and inexpensive way.

2. The prediction of banana nutritional status based on mathematical models is an important auxiliary tool that, combined with leaf and soil analyses, contributes to a more precise and secure evaluation.

**Literature Cited**


