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Kenworthy and DRIS norms for 'Prata-Anã' and 'BRS Platina' banana plants in improved fertility soils

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ABSTRACT: The objective was to establish and evaluate the similarity of the Kenworthy and DRIS norms for the Prata banana in soils with improved fertility. The data used were leaf nutrient contents and yields of 180 plots from an experiment with two cultivars (Prata-Anã and BRS Platina), five doses of K_2O (0; 200; 400; 600 and 800 kg ha^{-1}) supplied with sources for organic management and six evaluation times (210; 390; 570; 750; 930 and 1,110 days after planting), in a randomized block design in the factorial scheme, with three replicates. The database was separated from the average yield, 36.42 t ha^{-1} cycle^{-1} for 'Prata-Anã' and 38.4 t ha^{-1} cycle^{-1} for 'BRS Platina', into low-yielding population (LYP) and high-yielding population (HYP). Mean, standard deviation, coefficient of variation, variance and variance ratio (HYP/LYP) of nutrients and their bivariate ratios, direct (A/B) and inverse (B/A), were calculated. 'Prata-Anã' and 'BRS Platina' in HYP differed in terms of the means and variances for Kenworthy by 33.00%, for the DRIS, the means differed in 71.21% and variances in 43.18% of the cases. The Kenworthy and DRIS norms established support the specific nutritional diagnosis of 'Prata-Anã' and 'BRS Platina' banana plants grown in soils with improved fertility.
Keywords: *Musa* spp.; plant nutrition; leaf analysis; nutritional balance.

Normas Kenworthy e DRIS para bananeiras 'Prata-Anã' e 'BRS Platina' em solos de fertilidade construída

RESUMO: Objetivou-se estabelecer e avaliar a similaridade das normas Kenworthy e DRIS para bananeiras tipo Prata em solos com fertilidade construída. Utilizaram-se teores de nutrientes das folhas e produtividades de 180 parcelas, de experimento com duas cultivares (Prata-Anã e BRS Platina), cinco doses de K_2O (0; 200; 400; 600 e 800 kg ha^{-1}) supridas com fontes para manejo orgânico e seis épocas de avaliação (210; 390; 570; 750; 930 e 1.110 dias após plantio), em delineamento em blocos casualizados em esquema fatorial, com três repetições. Separou-se o banco de dados, a partir da produtividade média (36,42 t ha^{-1} ciclo^{-1} para a 'Prata-Anã' e de 38,4 t ha^{-1} ciclo^{-1} para a 'BRS Platina') em população de baixa (PBP) e alta produtividade (PAP). Calcularam-se as médias, desvio-padrão, coeficientes de variação, variâncias e razão das variâncias (PBP/PAP) dos nutrientes e de suas relações bivariadas, direta (A/B) e inversa (B/A). 'Prata-Anã' e 'BRS Platina' na PAP diferiram quanto às médias e variâncias para Kenworthy em 33,0%, já para o DRIS, médias diferiram em 71,21 % e variâncias em 43,18% dos casos. As normas Kenworthy e DRIS estabelecidas subsidiam o diagnóstico nutricional específico das bananeiras 'Prata-Anã' e 'BRS Platina' cultivadas em solos com fertilidade construída.
Palavras-chave: *Musa* spp.; nutrição de plantas; análise foliar; balanço nutricional.

1. INTRODUCTION

The methods for diagnosing the nutritional status of banana plants (*Musa* spp.) can be static when comparing the concentration of an element in the sample evaluated with its norm or dynamic when involving the ratios between the elements based on a pre-established norm. The joint use of these methods makes it possible to know: the degree of balance between nutrients by the Balanced Indices of Kenworthy (BIK) (Kenworthy, 1961), which incorporates variability and estimates the percentage of deviation of a given nutrient concentration relative to the norm; and the degree of balance and the orders of limitations between nutrients given by the Diagnosis and Recommendation Integrated System (DRIS) (Beaufils, 1973), a bivariate method that involves comparison of the relationships of each pair of nutrients with the norms.

Regardless of the method to be used, the proper establishment of norms is fundamental (Mourão Filho, 2004), because the interpretation of the results of tissue analyses considers comparisons with these standards. However, the norms differ between environments and banana cultivars (Rodrigues Filho et al., 2021b), as found by Pereira et al. (2015), who concluded that diagnoses generated with specific norms coincide in less than 60% with those found in the literature when considering universal norms. Therefore, the norms should be adjusted for site-specific conditions because they are more reliable for nutritional diagnosis.

For 'Prata-Anã' banana, DRIS norms have been established for Northern Minas Gerais (Silva; Carvalho, 2006), different regions of Ceará (Pereira et al., 2015; Lima Neto et al., 2021; Rodrigues Filho et al., 2021a,b), and Bahia, Ponto Novo region (Rodrigues Filho et al., 2021a,b), while BIK norms were established by Rodrigues Filho et al. (2021a,b) for Missão Velha, Ceará, and Ponto Novo, Bahia.

Despite that, nutrient contents may differ between banana cultivars within the same genomic group, as well as nutritional requirements and efficiencies between progenitor, 'Prata-Anã', and progeny, 'BRS Platina' (Silva et al., 2014; Souza et al., 2016), which requires adjustments of specific norms. Therefore, the objective was to establish and evaluate the similarity of BIK and DRIS norms for 'Prata' bananas in soils with improved fertility.

2. MATERIAL AND METHODS

2.1. Experimental conditions

The study was conducted in Guanambi, BA, Brazil (14°17'38" S, 42°41'42" W, average altitude of 537 m). The climate is semi-arid, hot and dry, with a well-defined dry season in winter and rainy season between October and March. The average annual precipitation is 672 mm, and the average annual temperature is 26 ºC (average of 40 years). The meteorological elements recorded in the experimental period are shown in Figure 1.

The soil, originally classified as medium-textured Latossolo Vermelho-Amarelo Distrófico (SiBCS), with 183 g kg^{-1} and 230 g kg^{-1} of clay at the depths of 0.0-0.2 and 0.2-0.4 m, respectively, corresponds to Oxisol (SOIL SURVEY STAFF - SSS, 1999). However, after correction, with two decades of applications of organic and chemical fertilizers and incorporation of crop remains, its fertility has been improved (Marques et al., 2022), and nutrient contents and base saturation were altered from a dystrophic to an eutrophic condition.

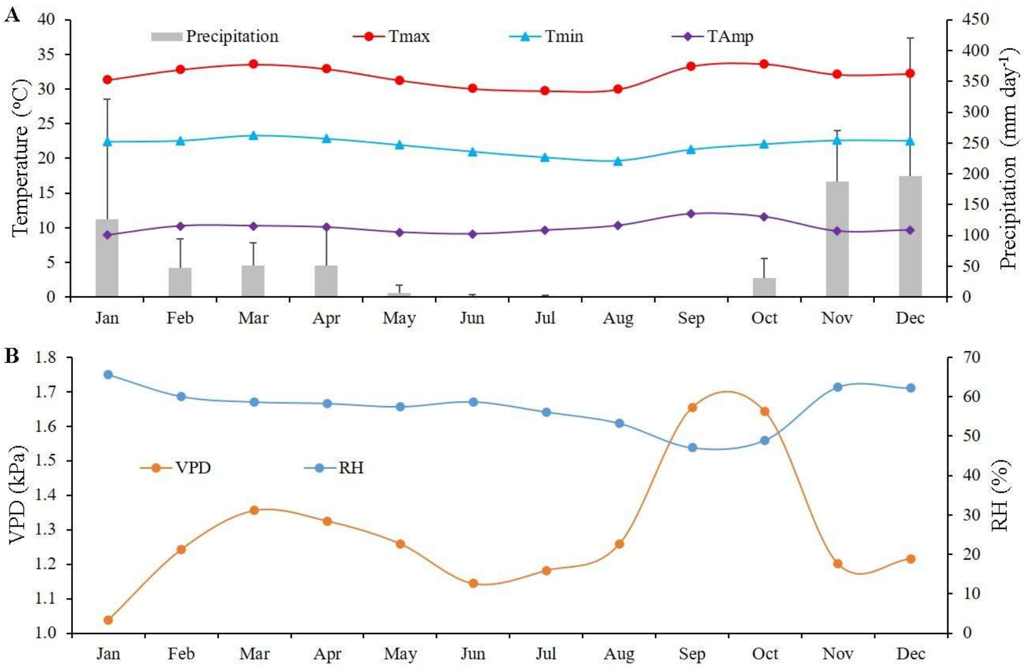

Figure 1. Average monthly values of meteorological data recorded between 08/01/2012 and 05/31/2016. Guanambi, BA. Note: Maximum temperature (T_{max}), Minimum temperature (T_{min}), Thermal Amplitude (TAmp) and Precipitation (P) – (**A**); Average atmospheric vapor pressure deficit (VPD) and average relative air humidity (RH) – (**B**). Source: Data collected at the automatic weather station installed in the experimental area of the Federal Institute Baiano.

Figura 1. Curso médio mensal dos dados meteorológicos registrados entre 01/08/2012 e 31/05/2016. Guanambi, BA. Nota: Temperatura máxima (T_{max}), mínima (T_{min}), amplitude térmica (TAmp) e Precipitação (P) – (**A**); Déficit de pressão de vapor médio da atmosfera (VPD) e umidade relativa média do ar (RH) – (**B**). Fonte: Dados coletados na estação meteorológica automática instalada na área experimental do Instituto Federal Baiano.

According to Marques et al. (2022), the average results of the chemical attributes of the soil before the banana plants were transplanted in the 0.0-0.2 m layer, were: 468.3 and 493.0 mg dm^{-3} of P and K; 0.1; 4.6 and 1.7 cmolc dm^{-3} of Na, Ca and Mg; 0.9; 2.2; 22.3; 46.5 and 40.8 mg dm^{-3} of B, Cu, Fe, Mn and Zn, respectively; pH (H_2O) = 7.4; Organic Matter (OM) (colorimetry) = 12.3 g kg^{-1}; Cation exchange capacity at pH 7 (T) = 8.4 cmolc dm^{-3}; and Base saturation (V) = 91%.

In the 0.2-0.4 m layer, the values were: 229.1 and 372.0 mg dm^{-3} of P and K; 0.1; 3.5 and 1.1 cmolc dm^{-3} of Na, Ca and Mg; 1.0; 1.2; 26.8; 27.7 and 8.7 mg dm^{-3} of B, Cu, Fe, Mn and Zn, respectively; pH = 7.3; OM= 1.7 g kg^{-1}; T = 6.5 cmolc dm^{-3}; and V = 89%. Mehlich-1 extractant was used for P, K, Na, Cu, Fe, Mn and Zn.

2.2. Database

A database (Marques et al., 2022; Santos et al., 2022a,b) was used containing the contents of nutrients (N, P, K, Ca, Mg, S, B, Cu, Fe, Mn and Zn) and Na in the leaves and the bunch yields (BY) of 180 plots (n=180) from an experiment with two Prata banana cultivars (Prata-Anã, AAB, progenitor, and its progeny, BRS Platina, AAAB), five doses of K_2O (0; 200; 400; 600 and 800 kg ha^{-1}) supplied with sources for organic management (bovine manure - 2.5 g kg^{-1} of K_2O and rock powder - 30 g kg^{-1} of K_2O) and six evaluation times (210; 390; 570; 750; 930 and 1,110 days after planting), in a randomized block design in a 2 × 5 × 6 factorial scheme, with three replicates, six usable plants and complete border. The average yield was 36.42 ± 8.4 t ha^{-1} ('Prata-Anã') (Santos et al., 2022a), and 38.40 ± 8.6 t ha^{-1} ('BRS Platina') (Santos et al., 2022b), over four production cycles.

Leaf tissue was sampled according to Costa et al. (2019). The samples were processed and analyzed for macronutrients (N, P, K, Ca, Mg and S) leaf contents, micronutrients (B, Cu, Fe, Mn and Zn) and Na. Analytical determinations were performed in the Soil Laboratory of the Agricultural Research Company of Minas Gerais - EPAMIG Norte. The yields were estimated in t ha^{-1} $cycle^{-1}$ by weighing the bunches during the harvests of each plot. The bunches were harvested when the central fruit of the outer row of fruits of the second hand had a minimum diameter of 32 mm, at the stage of completely green peel.

2.3. Experiment description

The experiment was set up and conducted according to Marques et al. (2022); Santos et al. (2022a, 2022b): spacing of 2.5 m × 2.0 m (2,000 plants ha^{-1}), irrigated by microsprinkler and conducted for four production cycles. The bovine manure used had, on a dry basis at 65 °C, on average: moisture content of 16.72%, organic matter content of 637.3 g kg^{-1}, pH of 7.42, density of 0.38 g cm^{-3} and the following contents of macronutrients (g kg^{-1}) - Ca = 1.7, Mg = 0.2, K = 2.5, N = 5.2, S = 2.3 and P = 4.7, and micronutrients (mg kg^{-1}) - B = 2.1, Cu = 45.2, Zn = 200.5, Mn = 391.8 and Fe = 1,932.4. The rock powder, natural earth of Ipirá, Naturalplus® from Terra Produtiva Mineradora Ltda., contained: 30.0 g kg^{-1} of K_2O (total), 10.0 g kg^{-1} of P_2O_5, 52.0 g kg^{-1} of CaO, 30.0 g kg^{-1} of MgO, 63.0 g kg^{-1} of Fe_2O_3, 1.5 g kg^{-1} of MnO, 630 g kg^{-1} of SiO_2, 69 mg kg^{-1} of Zn, 127 mg kg^{-1} of Cu and 5 mg kg^{-1} of OM. Fertilizer doses were split into six portions and applied every 60 days. Additionally, B and Zn were applied through the leaves until the flowering of the first production cycle and, from the second cycle onwards, B, Zn and Cu were applied through the rhizome of the cut sprout, and Mg was applied in the soil (MARQUES et al., 2022).

2.4. Data analysis

The results of leaf and yield analyses were organized and processed in a Microsoft Excel® spreadsheet.

For the establishment of BIK (Balance Indices of Kenworthy) and DRIS (Diagnosis and Recommendation Integrated System) norms, the database was divided according to cultivars (Prata-Anã, n = 90 and BRS Platina, n = 90). Then, the data set of each cultivar was subdivided into two subpopulations, classified as high-yielding population (HYP) and low-yielding population (LYP) as a function of the average bunch yield, with HYP being considered the reference population. For 'Prata-Anã', the reference population was the one with yield higher than 36.42 t ha^{-1} $cycle^{-1}$, corresponding to 50.00% of the banana leaf samples (n = 45) (SANTOS et al., 2022a). For 'BRS Platina', the reference population had yields above 38.4 t ha^{-1} $cycle^{-1}$, about 54.40% of the records (n = 49) (Santos et al., 2022b).

To compose the norms by the BIK method, the mean ($\bar{x}$), standard deviation (s), coefficient of variation (CV) and variance (s^2) of the contents of nutrients and Na of the high-yielding (HYP) and low-yielding (LYP) populations of each cultivar were calculated. To compose the DRIS norms, the $\bar{x}$, s, CV and s^2 of all bivariate ratios between nutrients and Na were calculated, considering the direct (A/B) and inverse (B/A) ratios of the relationships for the HYP and LYP of each cultivar. The dual ratios between nutrient contents (A/B and B/A) that had the highest ratios between the variances of LYP and HYP (s^2_L/s^2_H) were selected as the ones to be used as DRIS norms, according to Teixeira et al. (2019), as shown below (Equation 1):

If,

$$\left[\frac{s^2_{(LYP)\left(\frac{A}{B}\right)}}{s^2_{(HYP)\left(\frac{A}{B}\right)}}\right] > \left[\frac{s^2_{(LYP)\left(\frac{B}{A}\right)}}{s^2_{(HYP)\left(\frac{B}{A}\right)}}\right] \quad (01)$$

The A/B ratio was used to compose the norm; otherwise, B/A was used. where: s^2 = variance of the dual ratio between nutrients; LYP = low-yielding population and HYP = high-yielding population.

The BIK and DRIS norms were established using the results of leaf analyses of samples from HYP. Among the cultivars, the homogeneities of the variances of the ratios in HYP (s^2_H) and LYP (s^2_L) were compared by F test ($p \leq 0.05$) and the means were compared by Student's t-test ($p \leq 0.05$). Additionally, the relative frequencies (%) in which the means and variances of the BIK and DRIS norms were not significantly different were calculated.

3. RESULTS

For 'Prata-Anã' and 'BRS Platina' banana, the mean values ($\bar{x}$), standard deviations (s), coefficients of variations (CV) and variances (s^2) of the yields and leaf contents of the 12 nutrients (BIK norms) and their 132 direct and inverse bivariate ratios were obtained in the high-yielding (HYP) and low-yielding (LYP) populations. Of these, 66 dual ratios between nutrients were selected, 38 direct and 28 inverse for 'Prata-Anã' and 37 direct and 29 inverse for 'BRS Platina' (DRIS norms) (Table 1).

The bunch yields (BY) shown by both cultivars in the four production cycles were similar to each other and differed between cycles. Thus, it can be inferred that the average BY between the HYPs of the two cultivars was 44 t $cycle^{-1}$, 32.00% higher than the average shown by the LYP.

Table 1. Yield and Kenworthy (Nutrient contents in leaves) and DRIS (Dual relations between nutrients) norms for high-yielding and low-yielding populations of 'Prata-Anã' and 'BRS Platina' banana plants, fertilized with fertilizers for organic management in soil with improved fertility in the semi-arid region of the Bahia state, Brazil, and comparison between means and variance of the specific norms of the cultivars.
Tabela 1. Produtividade, normas Kenworthy (Teores de nutrientes nas folhas) e DRIS (Relações duais entre nutrientes) para populações de alta e baixa produtividade de bananeiras 'Prata-Anã' e 'BRS Platina', adubadas com fertilizantes para manejo orgânico em solo de fertilidade construída no semiárido do estado da Bahia, Brasil, e comparação entre médias e variâncias das normas específicas das cultivares.

	'Prata-Anã' (PA)									'BRS Platina' (PL)									PA × PL			
	---------HYP---------				---------LYP---------					---------HYP---------				---------LYP---------					HYP		LYP	
	$\bar{x}$	s_H	CV	s_H^2	$\bar{x}$	s_L	CV	s_L^2	$\frac{s_L^2}{s_H^2}$	$\bar{x}$	s_H	CV	s_H^2	$\bar{x}$	s_L	CV	s_L^2	$\frac{s_L^2}{s_H^2}$	$\bar{x}$	s_H^2	$\bar{x}$	s_L^2
BY	43.2	5.2	11.9	26.6	29.6	4.5	15	20.5	0.8	44.9	5.0	11.2	25.3	30.6	4.5	15	20.3	0.8	ns	ns	ns	ns
N	29.2	3.3	11.3	10.9	31.1	3.8	12	14.6	1.3	30.4	3.8	12.4	14.1	30.7	3.5	11	12.1	0.9	ns	ns	ns	ns
P	2.16	0.3	12.6	0.1	2.3	0.3	11	0.1	0.9	2.20	0.3	13.7	0.1	2.2	0.3	13	0.1	1.0	**	ns	**	ns
K	32.3	2.1	6.4	4.3	32.9	2.3	7	5.3	1.2	33.9	2.7	7.9	7.2	35.0	3.3	9	10.7	1.5	**	*	**	*
Ca	6.4	1.7	27.1	3.0	6.9	2.0	29	4.1	1.4	7.0	1.8	25.3	3.1	7.0	2.4	34	5.8	1.9	*	ns	ns	ns
Mg	4.4	0.7	14.7	0.4	4.9	1.5	31	2.2	5.2	4.4	0.6	13.9	0.4	4.2	0.8	20	0.7	1.8	ns	ns	**	**
S	2.3	0.4	17.5	0.2	2.3	0.4	18	0.2	1.2	2.5	0.5	19.0	0.2	2.4	0.5	19	0.2	0.9	**	ns	ns	ns
B	27.1	8.4	30.8	70.0	22.6	10.1	45	101.4	1.4	27.2	6.7	24.6	44.6	24.1	11.6	48	135.4	3.0	ns	ns	ns	ns
Cu	7.0	1.9	26.8	3.5	9.0	2.5	27	6.1	1.7	7.5	2.5	32.8	6.0	8.3	2.8	34	7.8	1.3	ns	*	ns	ns
Fe	103	38	37.4	1482	93	32	34	1010	0.7	127	49	38.4	2366	117	69	59	4749	2.0	ns	ns	ns	**
Mn	77.1	27.9	36.1	777.2	66.3	30.9	47	957.8	1.2	78.3	39.1	49.9	1530.4	68.6	30.8	45	946.7	0.6	ns	*	ns	ns
Zn	18.3	2.8	15.3	7.9	21.2	3.5	17	12.5	1.6	20.7	9.1	43.9	82.6	21.4	4.8	22	22.6	0.3	ns	**	ns	*
Na	29.7	13.6	45.7	184.8	26.8	9.5	35	89.5	0.5	33.0	13.0	39.3	168.8	33.8	14.3	42	205.1	1.2	ns	ns	ns	**
N/P	13.6	1.6	11.6	2.5	13.7	1.3	10	1.7	0.7	13.9	1.4	10.2	2.0	14.1	1.6	11	2.6	1.3	ns	ns	*	ns
P/N	0.1	0.0	11.2	0.0	0.1	0.0	10	0.0	0.8	0.1	0.0	36.9	0.0	0.1	0.1	51	0.0	3.3	**	**	**	**
N/K	0.9	0.1	11.3	0.0	0.9	0.1	11	0.0	1.1	0.9	0.1	12.0	0.0	0.9	0.1	11	0.0	0.8	**	ns	**	ns
K/N	1.1	0.1	10.3	0.0	1.1	0.1	11	0.0	1.1	1.1	0.1	12.3	0.0	1.1	0.1	10	0.0	0.7	**	ns	**	ns
N/Ca	4.8	1.2	24.0	1.3	4.9	1.6	33	2.5	1.9	4.5	1.0	21.0	0.9	5.0	2.1	41	4.3	4.7	**	ns	ns	*
Ca/N	0.2	0.0	22.2	0.0	0.2	0.1	28	0.0	1.7	0.2	0.0	18.4	0.0	0.2	0.1	35	0.0	3.7	**	ns	**	ns
N/Mg	6.7	0.9	13.5	0.8	6.8	1.6	23	2.5	3.1	6.9	0.7	10.4	0.5	7.7	1.8	24	3.3	6.4	**	ns	**	ns
Mg/N	0.2	0.0	12.8	0.0	0.2	0.0	26	0.0	4.3	0.1	0.0	10.4	0.0	0.1	0.0	22	0.0	3.9	**	*	**	*
N/S	13.1	2.2	17.1	5.0	13.5	1.7	13	3.0	0.6	12.4	2.5	20.3	6.4	13.3	2.0	15	4.2	0.7	ns	ns	ns	ns
S/N	0.1	0.0	15.6	0.0	0.1	0.0	13	0.0	0.6	0.1	0.0	17.0	0.0	0.1	0.0	16	0.0	0.8	**	ns	**	ns
N/B	1.2	0.4	31.8	0.1	1.6	0.7	41	0.5	3.3	1.2	0.4	33.9	0.2	1.6	0.9	53	0.7	4.4	*	ns	ns	ns
B/N	0.9	0.3	33.8	0.1	0.7	0.4	52	0.1	1.5	0.9	0.3	30.4	0.1	0.8	0.4	55	0.2	2.6	**	ns	**	ns
N/Cu	4.5	1.5	32.7	2.2	3.7	0.9	26	0.9	0.4	4.4	1.0	23.8	1.1	4.1	1.3	32	1.7	1.6	ns	**	**	*
Cu/N	0.2	0.1	26.0	0.0	0.3	0.1	23	0.0	1.1	0.2	0.1	23.6	0.0	0.3	0.1	27	0.0	1.5	**	ns	**	ns
N/Fe	0.3	0.1	36.8	0.0	0.4	0.1	27	0.0	0.7	0.3	0.1	33.2	0.0	0.3	0.1	39	0.0	2.0	**	*	**	ns
Fe/N	3.6	1.4	40.2	2.1	3.0	0.9	30	0.8	0.4	4.2	1.8	43.4	3.4	3.8	2.3	60	5.2	1.6	**	ns	**	**
N/Mn	0.4	0.2	39.7	0.0	0.6	0.3	49	0.1	2.9	0.5	0.2	44.7	0.0	0.5	0.2	43	0.1	1.1	**	ns	**	ns
Mn/N	2.6	0.9	35.8	0.9	2.1	0.9	43	0.8	0.9	2.6	1.3	49.0	1.6	2.2	0.9	41	0.8	0.5	ns	*	ns	ns
N/Zn	1.6	0.3	16.4	0.1	1.5	0.2	14	0.0	0.6	1.6	0.3	21.6	0.1	1.5	0.3	19	0.1	0.7	**	*	ns	*
Zn/N	0.6	0.1	15.1	0.0	0.7	0.1	14	0.0	1.0	0.7	0.2	34.0	0.1	0.7	0.1	18	0.0	0.3	**	**	**	*
N/Na	1.2	0.5	45.5	0.3	1.3	0.4	30	0.1	0.5	1.0	0.3	30.6	0.1	1.0	0.4	37	0.1	1.5	**	**	**	ns
Na/N	1.0	0.5	49.5	0.3	0.9	0.3	33	0.1	0.3	1.1	0.4	40.3	0.2	1.1	0.5	45	0.3	1.3	**	ns	**	**
P/K	0.1	0.0	10.6	0.0	0.1	0.0	11	0.0	1.2	0.1	0.0	10.8	0.0	0.1	0.0	12	0.0	1.1	**	ns	**	ns
K/P	15.1	1.7	11.0	2.8	14.5	1.7	12	2.8	1.0	15.6	1.7	11.0	3.0	16.1	1.8	12	3.4	1.1	*	ns	**	ns
P/Ca	0.4	0.1	30.6	0.0	0.4	0.1	35	0.0	1.3	0.3	0.1	21.9	0.0	0.4	0.1	40	0.0	3.9	**	**	*	ns
Ca/P	3.0	0.8	27.0	0.7	3.1	0.9	29	0.8	1.2	3.2	0.7	20.9	0.4	3.2	1.1	34	1.2	2.7	**	ns	ns	ns
P/Mg	0.5	0.1	15.4	0.0	0.5	0.1	24	0.0	2.5	0.5	0.1	11.1	0.0	0.5	0.1	21	0.0	4.3	**	*	**	ns
Mg/P	2.1	0.3	15.0	0.1	2.1	0.6	27	0.3	3.5	2.0	0.2	11.8	0.1	1.9	0.4	20	0.1	2.5	**	*	**	**
P/S	1.0	0.2	17.3	0.0	1.0	0.2	16	0.0	0.9	0.9	0.2	21.5	0.0	0.9	0.1	13	0.0	0.4	**	ns	**	ns
S/P	1.1	0.2	14.4	0.0	1.0	0.2	16	0.0	1.2	1.2	0.2	17.6	0.0	1.1	0.2	14	0.0	0.6	**	*	**	ns
P/B	0.1	0.0	32.9	0.0	0.1	0.0	40	0.0	2.8	0.1	0.0	36.9	0.0	0.1	0.1	51	0.0	3.3	**	ns	**	ns
B/P	12.9	4.8	37.0	22.7	10.0	4.7	47	22.0	1.0	12.7	3.9	30.9	15.4	11.2	5.7	51	32.3	2.1	ns	ns	ns	ns
P/Cu	0.3	0.1	24.8	0.0	0.3	0.1	27	0.0	0.8	0.3	0.1	20.8	0.0	0.3	0.1	29	0.0	1.7	**	ns	**	ns
Cu/P	3.2	0.7	21.6	0.5	3.9	0.9	24	0.9	1.8	3.3	0.7	20.9	0.5	3.7	1.0	28	1.1	2.2	**	ns	*	ns
P/Fe	0.0	0.0	35.9	0.0	0.0	0.0	30	0.0	0.9	0.0	0.0	32.8	0.0	0.0	0.0	36	0.0	1.7	**	*	**	ns
Fe/P	48.5	20.4	42.1	416.6	40.7	12.6	31	157.9	0.4	58.0	22.6	39.0	512.2	52.6	28.6	54	816.2	1.6	ns	ns	ns	**
P/Mn	0.0	0.0	41.9	0.0	0.0	0.0	51	0.0	2.6	0.0	0.0	45.1	0.0	0.0	0.0	43	0.0	1.1	**	ns	**	*
Mn/P	36.2	14.1	39.0	199.8	28.7	12.6	44	159.6	0.8	35.9	18.0	50.3	325.7	31.1	13.2	43	174.9	0.5	ns	ns	ns	ns
P/Zn	0.1	0.0	15.7	0.0	0.1	0.0	14	0.0	0.7	0.1	0.0	21.5	0.0	0.1	0.0	18	0.0	0.6	**	*	**	ns
Zn/P	8.6	1.4	16.5	2.0	9.3	1.2	13	1.5	0.8	9.3	3.3	35.8	11.2	9.6	1.5	15	2.1	0.2	ns	**	*	ns
P/Na	0.1	0.0	47.7	0.0	0.1	0.0	31	0.0	0.5	0.1	0.0	31.3	0.0	0.1	0.0	35	0.0	1.3	**	**	**	ns
Na/P	14.1	6.8	48.1	45.6	11.8	4.3	36	18.6	0.4	15.2	5.9	39.2	35.3	15.4	6.5	42	41.8	1.2	ns	ns	ns	**
K/Ca	5.4	1.5	28.5	2.4	5.2	1.7	33	3.0	1.2	13.8	3.3	23.7	10.7	15.0	2.8	18	7.6	0.7	**	**	**	**
Ca/K	0.2	0.1	28.2	0.0	0.2	0.1	29	0.0	1.2	0.2	0.0	21.5	0.0	0.2	0.1	40	0.0	3.5	**	ns	**	*
K/Mg	7.4	1.1	14.9	1.2	7.2	1.8	25	3.3	2.7	7.8	1.0	12.5	0.9	8.8	2.2	26	5.0	5.4	**	ns	**	ns
Mg/K	0.1	0.0	15.5	0.0	0.1	0.0	29	0.0	3.9	0.1	0.0	11.8	0.0	0.1	0.0	25	0.0	3.8	**	*	**	*
K/S	14.6	2.7	18.4	7.2	14.4	2.4	17	6.0	0.8	14.0	2.9	21.1	8.7	15.2	2.6	17	6.6	0.8	ns	ns	ns	ns
S/K	0.1	0.0	17.1	0.0	0.1	0.0	16	0.0	0.8	0.1	0.0	20.0	0.0	0.1	0.0	20	0.0	0.8	**	ns	**	ns

K/B	1.3	0.4	28.3	0.1	1.7	0.7	40	0.5	3.5	1.3	0.4	30.8	0.2	1.8	1.0	54	1.0	5.7	**	ns	ns	*
B/K	0.8	0.3	34.3	0.1	0.7	0.3	48	0.1	1.3	0.8	0.2	26.4	0.0	0.7	0.4	52	0.1	3.0	**	*	ns	ns
K/Cu	5.0	1.6	31.6	2.5	4.0	1.2	31	1.5	0.6	4.9	1.4	29.0	2.0	4.7	1.7	35	2.7	1.3	ns	ns	**	*
Cu/K	0.2	0.1	25.3	0.0	0.3	0.1	27	0.0	1.8	0.2	0.1	27.5	0.0	0.2	0.1	31	0.0	1.4	**	ns	**	ns
K/Fe	0.4	0.1	37.1	0.0	0.4	0.1	30	0.0	0.8	0.3	0.1	35.2	0.0	0.4	0.2	40	0.0	2.0	**	ns	**	ns
Fe/K	3.2	1.3	40.8	1.7	2.8	0.9	33	0.9	0.5	3.7	1.4	37.6	2.0	3.4	2.1	61	4.3	2.2	**	ns	*	**
K/Mn	0.5	0.2	39.4	0.0	0.6	0.3	53	0.1	3.1	0.5	0.3	49.7	0.1	0.6	0.3	44	0.1	1.0	**	*	ns	ns
Mn/K	2.4	0.9	38.1	0.8	2.0	0.9	45	0.8	1.0	2.3	1.1	48.3	1.2	2.0	0.9	45	0.8	0.6	ns	ns	ns	ns
K/Zn	1.8	0.3	15.9	0.1	1.6	0.3	17	0.1	0.9	1.8	0.4	23.4	0.2	1.7	0.4	22	0.1	0.8	ns	**	**	*
Zn/K	0.6	0.1	16.3	0.0	0.6	0.1	16	0.0	1.3	0.6	0.2	37.7	0.1	0.6	0.1	21	0.0	0.3	**	**	**	ns
K/Na	1.3	0.6	42.3	0.3	1.4	0.4	30	0.2	0.5	1.1	0.3	30.5	0.1	1.2	0.4	37	0.2	1.6	**	**	**	ns
Na/K	0.9	0.4	46.6	0.2	0.8	0.3	36	0.1	0.5	1.0	0.4	38.7	0.1	1.0	0.4	43	0.2	1.3	**	ns	**	*
Ca/Mg	1.4	0.3	22.0	0.1	1.5	0.3	22	0.1	1.0	1.6	0.2	15.4	0.1	1.6	0.4	22	0.1	2.2	**	*	**	ns
Mg/Ca	0.7	0.1	20.1	0.0	0.7	0.2	22	0.0	1.2	0.7	0.1	16.7	0.0	0.6	0.2	25	0.0	2.2	**	*	**	ns
Ca/S	2.8	0.7	23.2	0.4	3.0	0.8	26	0.6	1.4	2.8	0.8	27.3	0.6	3.0	1.1	35	1.1	1.9	ns	ns	ns	*
S/Ca	0.4	0.1	26.7	0.0	0.4	0.1	28	0.0	1.0	0.4	0.1	28.6	0.0	0.4	0.2	50	0.0	3.1	**	ns	**	**
Ca/B	0.3	0.1	40.4	0.0	0.3	0.1	42	0.0	2.1	0.3	0.1	42.0	0.0	0.3	0.1	38	0.0	1.1	**	ns	**	ns
B/Ca	4.5	1.5	34.1	2.3	3.4	1.6	47	2.5	1.1	4.1	1.3	31.9	1.7	3.6	1.7	48	3.1	1.8	*	ns	ns	ns
Ca/Cu	1.0	0.4	39.0	0.1	0.8	0.3	39	0.1	0.7	1.0	0.2	23.9	0.1	1.0	0.5	48	0.2	3.7	ns	**	**	*
Cu/Ca	1.2	0.5	38.9	0.2	1.4	0.7	50	0.5	2.5	1.1	0.3	25.3	0.1	1.4	0.8	55	0.6	7.6	**	**	ns	ns
Ca/Fe	0.1	0.0	39.8	0.0	0.1	0.0	27	0.0	0.6	0.1	0.0	34.6	0.0	0.1	0.0	44	0.0	2.2	**	*	**	**
Fe/Ca	16.9	6.7	39.6	44.7	13.8	3.6	26	13.1	0.3	18.8	7.7	41.1	59.5	17.8	10.6	60	112.6	1.9	ns	ns	ns	**
Ca/Mn	0.1	0.0	39.4	0.0	0.1	0.1	47	0.0	2.8	0.1	0.0	40.4	0.0	0.1	0.1	46	0.0	1.7	**	ns	**	ns
Mn/Ca	12.4	4.1	33.0	16.7	9.9	5.0	51	25.3	1.5	11.4	5.6	49.3	31.7	11.1	7.3	65	52.9	1.7	ns	*	ns	**
Ca/Zn	0.3	0.1	22.8	0.0	0.3	0.1	26	0.0	1.2	0.4	0.1	19.2	0.0	0.3	0.1	36	0.0	3.3	**	ns	**	*
Zn/Ca	3.0	0.8	24.9	0.6	3.3	1.0	31	1.0	1.8	3.0	0.8	27.9	0.7	3.5	1.7	48	2.8	4.1	ns	ns	ns	**
Ca/Na	0.3	0.1	48.1	0.0	0.3	0.1	39	0.0	0.8	0.2	0.1	33.4	0.0	0.2	0.1	44	0.0	1.8	**	**	**	ns
Na/Ca	5.0	2.9	57.1	8.2	4.2	2.4	56	5.6	0.7	4.9	2.0	40.3	3.9	5.4	3.1	57	9.7	2.5	ns	**	ns	*
Mg/S	2.0	0.3	15.2	0.1	2.1	0.5	23	0.2	2.7	1.8	0.3	19.2	0.1	1.8	0.4	23	0.2	1.4	**	ns	**	ns
S/Mg	0.5	0.1	16.3	0.0	0.5	0.1	23	0.0	1.8	0.6	0.1	17.2	0.0	0.6	0.1	24	0.0	2.0	**	ns	**	ns
Mg/B	0.2	0.1	30.2	0.0	0.2	0.1	36	0.0	2.8	0.2	0.1	33.0	0.0	0.2	0.1	34	0.0	1.4	*	ns	**	ns
B/Mg	6.2	1.8	29.5	3.3	4.8	2.0	43	4.1	1.2	6.3	1.8	29.4	3.4	5.7	2.4	42	5.8	1.7	ns	ns	*	ns
Mg/Cu	0.7	0.2	34.1	0.1	0.6	0.2	39	0.1	0.9	0.6	0.2	24.6	0.0	0.6	0.2	40	0.1	2.2	**	**	**	ns
Cu/Mg	1.6	0.5	28.4	0.2	2.0	0.8	40	0.6	3.1	1.7	0.4	25.2	0.2	2.1	0.9	44	0.8	4.7	**	ns	ns	ns
Mg/Fe	0.0	0.0	33.1	0.0	0.1	0.0	21	0.0	0.5	0.0	0.0	32.7	0.0	0.0	0.0	35	0.0	1.4	**	ns	**	*
Fe/Mg	23.4	8.8	37.5	76.7	19.3	4.3	22	18.8	0.2	28.9	12.2	42.3	149.7	27.3	12.4	46	154.6	1.0	ns	*	ns	**
Mg/Mn	0.1	0.0	33.8	0.0	0.1	0.0	44	0.0	3.2	0.1	0.0	42.1	0.0	0.1	0.0	42	0.0	1.1	**	*	**	ns
Mn/Mg	17.3	5.6	32.2	31.1	13.9	6.5	47	42.8	1.4	17.6	8.5	48.2	72.0	16.6	7.5	45	55.6	0.8	ns	**	ns	ns
Mg/Zn	0.2	0.0	15.3	0.0	0.2	0.1	26	0.0	2.5	0.2	0.0	20.3	0.0	0.2	0.1	29	0.0	1.6	**	ns	**	ns
Zn/Mg	4.2	0.7	16.3	0.5	4.6	1.0	22	1.0	2.1	4.6	1.6	34.1	2.5	5.3	1.6	29	2.4	1.0	**	**	**	**
Mg/Na	0.2	0.1	45.5	0.0	0.2	0.1	37	0.0	0.8	0.1	0.0	29.9	0.0	0.1	0.1	37	0.0	1.4	**	**	**	*
Na/Mg	6.9	3.5	50.8	12.3	5.9	2.9	49	8.5	0.7	7.5	3.1	41.2	9.7	8.3	3.9	47	15.6	1.6	ns	ns	*	*
S/B	0.1	0.0	32.3	0.0	0.1	0.1	41	0.0	2.9	0.1	0.0	34.8	0.0	0.1	0.1	54	0.0	3.7	**	ns	**	*
B/S	12.1	3.9	32.2	15.3	9.9	4.9	49	23.8	1.6	11.3	3.7	32.8	13.6	10.6	5.3	50	27.8	2.0	ns	ns	ns	ns
S/Cu	0.3	0.1	27.3	0.0	0.3	0.1	25	0.0	0.5	0.4	0.1	30.4	0.0	0.3	0.1	31	0.0	0.7	**	ns	**	*
Cu/S	3.1	0.7	22.7	0.5	3.9	1.0	25	0.9	1.9	3.0	1.1	35.1	1.1	3.5	1.1	31	1.2	1.1	ns	**	**	ns
S/Fe	0.0	0.0	34.0	0.0	0.0	0.0	25	0.0	0.7	0.0	0.0	35.1	0.0	0.0	0.0	35	0.0	1.2	**	ns	**	ns
Fe/S	45.9	17.9	38.9	318.9	39.8	11.2	28	126.5	0.4	52.1	23.9	45.9	572.8	49.9	30.6	61	935.5	1.6	ns	*	ns	**
S/Mn	0.0	0.0	37.0	0.0	0.0	0.0	47	0.0	2.7	0.0	0.0	45.5	0.0	0.0	0.0	43	0.0	0.9	**	**	**	ns
Mn/S	34.2	12.2	35.8	149.3	28.0	11.3	40	126.7	0.8	31.9	17.3	54.2	299.7	29.1	12.1	42	146.8	0.5	ns	*	ns	ns
S/Zn	0.1	0.0	17.8	0.0	0.1	0.0	17	0.0	0.7	0.1	0.0	30.6	0.0	0.1	0.0	22	0.0	0.4	**	**	**	*
Zn/S	8.2	1.5	18.2	2.2	9.2	1.3	15	1.8	0.8	8.5	4.0	46.6	15.6	9.1	1.8	19	3.1	0.2	ns	**	ns	*
S/Na	0.1	0.0	53.1	0.0	0.1	0.0	35	0.0	0.5	0.1	0.0	34.0	0.0	0.1	0.0	35	0.0	0.9	**	**	**	ns
Na/S	13.7	7.3	53.6	53.9	11.7	4.4	37	19.2	0.4	13.8	7.5	54.5	56.9	14.5	6.5	45	42.8	0.8	ns	ns	ns	**
B/Cu	4.4	2.8	64.5	7.9	2.9	1.8	62	3.1	0.4	4.1	1.7	41.0	2.8	3.5	2.3	65	5.2	1.9	ns	**	ns	ns
Cu/B	0.3	0.1	40.5	0.0	0.5	0.3	57	0.1	5.9	0.3	0.2	55.6	0.0	0.5	0.3	73	0.1	4.0	**	**	**	ns
B/Fe	0.3	0.1	34.2	0.0	0.3	0.1	43	0.0	1.3	0.2	0.1	35.0	0.0	0.2	0.1	54	0.0	2.4	**	ns	**	ns
Fe/B	4.0	1.5	38.2	2.3	4.6	1.7	38	3.0	1.3	4.8	1.8	37.2	3.2	5.4	2.8	52	7.8	2.4	**	ns	ns	**
B/Mn	0.4	0.1	38.1	0.0	0.4	0.3	62	0.1	3.1	0.4	0.2	52.8	0.1	0.4	0.3	69	0.1	1.6	**	**	ns	ns
Mn/B	3.0	1.4	45.9	1.9	3.4	2.1	62	4.4	2.3	3.0	1.5	49.0	2.2	3.4	1.9	56	3.6	1.7	ns	ns	ns	ns
B/Zn	1.5	0.5	31.9	0.2	1.1	0.5	46	0.3	1.1	1.5	0.5	34.8	0.3	1.2	0.7	55	0.5	1.8	*	ns	**	*
Zn/B	0.7	0.2	33.0	0.1	1.1	0.4	40	0.2	3.2	0.8	0.5	63.2	0.3	1.1	0.7	60	0.5	1.7	**	**	ns	**
B/Na	1.1	0.5	50.1	0.3	0.9	0.5	58	0.3	1.0	0.9	0.3	29.9	0.1	0.8	0.4	47	0.1	1.9	**	**	**	**
Na/B	1.2	0.6	52.7	0.4	1.4	0.8	57	0.7	1.7	1.2	0.5	36.1	0.2	1.7	1.1	66	1.3	6.1	**	*	**	*
Cu/Fe	0.1	0.0	38.9	0.0	0.1	0.0	45	0.0	2.5	0.1	0.0	37.0	0.0	0.1	0.0	50	0.0	3.4	**	ns	**	ns
Fe/Cu	16.5	11.0	66.5	120.1	11.1	4.8	43	23.1	0.2	18.3	9.7	53.0	94.4	15.5	9.6	62	91.6	1.0	ns	ns	ns	**
Cu/Mn	0.1	0.0	45.2	0.0	0.2	0.1	65	0.0	5.7	0.1	0.1	45.8	0.0	0.1	0.1	63	0.0	3.0	**	ns	**	ns
Mn/Cu	12.2	7.2	59.6	52.5	7.7	3.7	48	13.7	0.3	11.2	6.4	56.5	40.4	9.1	4.4	49	19.7	0.5	ns	ns	ns	ns
Cu/Zn	0.4	0.1	25.4	0.0	0.4	0.1	24	0.0	1.1	0.4	0.1	22.5	0.0	0.4	0.1	24	0.0	1.2	**	ns	**	ns
Zn/Cu	2.8	0.9	32.0	0.8	2.5	0.6	25	0.4	0.5	2.8	0.8	28.1	0.6	2.7	0.6	22	0.4	0.6	ns	ns	**	ns
Cu/Na	0.3	0.2	54.6	0.0	0.4	0.2	42	0.0	1.0	0.2	0.1	41.2	0.0	0.3	0.1	46	0.0	1.5	**	**	**	ns
Na/Cu	4.7	2.7	56.7	7.0	3.2	1.3	41	1.7	0.2	4.7	1.8	38.8	3.3	4.5	2.6	57	6.6	2.0	ns	**	**	**

Fe/Mn	1.4	0.5	33.2	0.2	1.6	0.5	34	0.3	1.4	1.8	0.8	42.6	0.6	1.8	1.0	52	0.9	1.5	**	**	**	**
Mn/Fe	0.8	0.3	34.9	0.1	0.7	0.3	39	0.1	1.0	0.6	0.3	42.3	0.1	0.7	0.3	45	0.1	1.2	**	ns	**	ns
Fe/Zn	5.6	1.9	34.7	3.8	4.4	1.1	25	1.2	0.3	6.5	2.4	37.3	5.8	5.5	3.0	54	8.9	1.5	*	ns	*	**
Zn/Fe	0.2	0.1	33.0	0.0	0.2	0.1	25	0.0	0.9	0.2	0.1	37.7	0.0	0.2	0.1	37	0.0	1.5	**	ns	**	*
Fe/Na	3.9	1.8	46.3	3.3	3.8	1.5	40	2.3	0.7	4.1	1.5	37.2	2.3	3.9	2.9	74	8.5	3.7	ns	ns	ns	**
Na/Fe	0.3	0.2	50.8	0.0	0.3	0.1	47	0.0	0.9	0.3	0.1	40.7	0.0	0.4	0.2	53	0.0	2.7	**	*	**	ns
Mn/Zn	4.2	1.4	32.6	1.9	3.1	1.4	44	1.8	1.0	4.0	1.9	47.6	3.6	3.3	1.4	43	2.0	0.5	ns	*	ns	ns
Zn/Mn	0.3	0.1	37.8	0.0	0.4	0.2	48	0.0	3.5	0.3	0.2	53.2	0.0	0.4	0.2	44	0.0	1.0	**	**	**	ns
Mn/Na	3.1	1.8	57.6	3.1	2.6	1.4	52	1.9	0.6	2.5	1.3	49.9	1.6	2.3	1.3	55	1.6	1.0	**	*	ns	ns
Na/Mn	0.4	0.3	61.6	0.1	0.5	0.3	57	0.1	1.1	0.5	0.3	55.8	0.1	0.6	0.5	75	0.2	2.6	**	ns	**	**
Zn/Na	0.7	0.3	45.4	0.1	0.9	0.2	29	0.1	0.5	0.7	0.3	39.3	0.1	0.7	0.3	41	0.1	1.2	**	ns	**	ns
Na/Zn	1.7	0.8	47.7	0.6	1.3	0.5	38	0.2	0.4	1.7	0.6	37.3	0.4	1.6	0.7	45	0.5	1.3	ns	ns	**	**

Norms: contents and dual ratios of the reference population (≥ average yield). Leaf contents of N, P, K, Ca, Mg and S are expressed in g kg^{-1} and leaf contents of Cu, Fe, Zn, Mn, B and Na in mg kg^{-1}; $\bar{x}$: mean leaf content and mean dual ratio; s_H and s_L: standard deviation of the high-yielding and low-yielding population, respectively; CV: coefficient of variation (%); s_H^2 and s_L^2: variance of the high-yielding and low-yielding population, respectively; s^2_L/s^2_H: variance ratio of the low-yielding population (LYP) to the high-yielding population (HYP) (Selected relationships are underlined); BY: Bunch Yield; PA: ‘Prata-Anã’; PL: ‘BRS Platina’; ^{ns}: not significant; *: significant (p≤0.05); **: significant (p≤0.01) by the Student’s t-test for the means and by the F test for the variances.
Normas: teores e razões duais médias das populações de referência (≥ rendimento médio). As concentrações foliares de N, P, K, Ca, Mg e S estão expressas em g kg^{-1} e Cu, Fe, Zn, Mn, B e Na em mg kg^{-1}; $\bar{x}$: concentração média foliar e razão dupla média; s_H e s_L: desvio padrão da população de alta e baixa produtividade, respectivamente; CV: coeficiente de variação (%); s_H^2 e s_L^2: variância da população de alta e baixa produtividade, respectivamente; s^2_L/s^2_H: razões de variância da população de baixa produtividade (LYP) em relação a população de alta produtividade (HYP) (Relações selecionadas estão sublinhadas); BY: Produtividade de pencas; PA: ‘Prata-Anã’; PL: ‘BRS Platina”; ^{ns}: não significativo; *: significativo (p≤0,05), **: significativo (p≤0,01) pelo teste t para as médias e teste F para as variâncias.

According to BIK norms, the HYPs of the cultivars Prata-Anã and BRS Platina differed for the mean contents of P, K, Ca and S in the same frequency (33.30%) as the variances of K, Cu, Mn and Zn of the 12 nutrients evaluated. In both cases (mean and variance), the highest values were observed for the BRS Platina cultivar.

In LYP, the frequency of nutrients with different BIK norms was 25.00% (P, K, Mg) between the values of the mean contents and 41.67% (K, Mg, Fe, Zn and Na) between the variances. In this situation, ‘Prata-Anã’ had the highest mean contents of P and Mg. On the other hand, the cultivar BRS Platina had higher variance values for K, Zn and Na.

In general, K had the lowest CV (< 10.00%) among the nutrients of both populations of the two cultivars evaluated. In addition, it stood out among the cultivars for the significant differences shown by the means and the variances of HYP and LYP. Generally, this nutrient had the highest means and variances in the BRS Platina cultivar than Prata-Anã. The cultivar BRS Platina showed coefficients of variation (CV) higher than 20.00% for all micronutrients and Ca and Na in both HYP and LYP. However, in LYP, the CV values were higher than those of the reference population, except for Mn and Zn, which were higher in HYP.

In the cultivar Prata-Anã, nutrients with CV higher than 20.00% were similar to those shown by ‘BRS Platina’, with an increase of Mg in LYP, and the exception of Zn, in both HYP (CV= 15.00%) and LYP (CV= 17.00%).

From the analysis of the DRIS norms, it can be inferred that, of the 132 bivariate ratios between nutrients in HYP, 94 (71.21%) showed mean values with significant differences between the cultivars Prata-Anã and BRS Platina. Regarding variances, 57 ratios (43.18%) with significant differences were observed. In LYP, the significant differences in the mean contents of nutrient ratios between the cultivars were found in 69.70% of the cases, i.e., 92 ratios (direct or inverse) between nutrients. The F test between the cultivars showed significant differences in 53 ratios between nutrients for variances (40.15% of the cases).

For all 132 dual ratios, the lowest CV found was 10.00% for both populations of the two cultivars. In all cases, N was part of the ratios with the lowest CV; however, there was a divergence in the K/N ratio between the cultivars. This ratio represented the lowest CV in HYP for ‘Prata-Anã’ and in LYP for ‘BRS Platina’.

Of the 66 ratios between nutrients selected to compose the DRIS norms for ‘BRS Platina,’ 10 had CV lower than 20.00% in HYP and only 7 in LYP. As for the variances constituting the DRIS norms, 39 showed significant differences. These ratios comprise B and Ca (11 ratios), P, Mg, Cu and Fe (7 ratios), Na (6 ratios), K and S (5 ratios) and N, Mn and Zn (4 ratios).

For ‘Prata-Anã’, of the 66 ratios selected by DRIS norms, 15 showed CV lower than 20.00% in HYP, and 10 in LYP. It was also verified that, of the selected ratios, 38 showed significant differences between s^2_L and s^2_H. These ratios included B (10 ratios), Mg and Mn (9 ratios), Cu (8 ratios), Ca and Na (6 ratios), N, P, K, S and Zn (5 ratios) and Fe (3 ratios).

It is worth pointing out that the HYP of the cultivar BRS Platina was formed mostly (54.00%) by samples from plots treated with the highest supplies of nutrients by fertilizers for organic management (600 and 800 kg ha^{-1} year^{-1} of K_2O) (Figure 2).

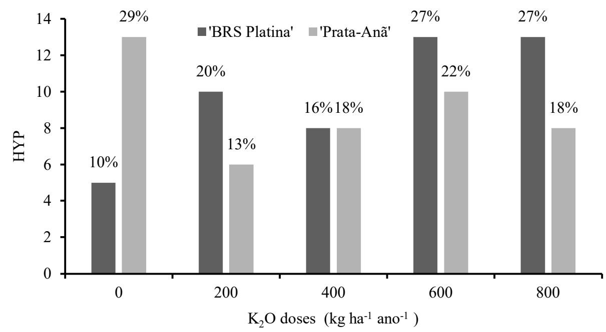

Figure 2. Distribution of leaf samples of the high-yielding population (HYP) of the cultivars BRS Platina (n= 49) and Prata-Anã (n= 45) as a function of fertilization with different doses of K_2O, from fertilizers for organic management (bovine manure - 2.5 g kg^{-1} of K_2O and rock powder - 30 g kg^{-1} of K_2O).
Figura 2. Distribuição das amostras foliares da população de alta produtividade (HYP) das cultivares BRS Platina (n= 49) e Prata-Anã (n= 45) em função das adubações com as diferentes doses de K_2O, provenientes de fertilizantes para manejo orgânico (esterco bovino 2,5 g kg^{-1} de K_2O e farinha de rocha 30 g kg^{-1} de K_2O).

On the other hand, in 'Prata-Anã' the treatment without organic fertilization had a participation greatly in the formation of PAP, around 29.00% of the samples evaluated, a value higher than those of the other treatments.

4. DISCUSSION

The similarity in bunch productivity (BP) presented by both cultivars corroborated other studies (MARQUES et al., 2018, 2022). For the Prata-Anã cultivar, Rodrigues Filho et al. (2021a) verified similar yields when cultivated in different regions (states of Ceará and Bahia), with an average yield of 35.4 t ha^{-1} $year^{-1}$. Since 'BRS Platina' is a progeny hybrid of the Prata-Anã cultivar, the similarity between the production potentials of genotypes is justifiable.

Differences between yields of LYP and HYP populations allow HYP to be used to obtain reference nutritional norms. According to Silva; Carvalho (2006), the average value of ratios among nutrients is assumed to be closer to the crop's physiological optimum in high-yield populations.

In Kenworthy (BIK) norms, in PAPs between cultivars under study, the similarity in the frequency of statistical differences shown by both mean contents and variances corroborate results obtained by Rodrigues Filho et al. (2021a), who reported the same behavior when comparing specific norms between Prata-Anã (AAB) and Grande Naine (AAA) banana cultivars cultivated in the state of Bahia, as well as norms for 'Prata-Anã' banana cultivar cultivated in the states of Ceará and Bahia. In these cases, the authors observed 54.50% and 90.90% frequencies, respectively. These much higher magnitudes observed by the abovementioned authors are justified because they compared cultivars of contrasting genomic groups (AAB and AAA) cultivated in different environments.

In a low-yielding population (LYP), the higher average P and Mg levels found for the Prata-Anã cultivar may be related to the synergy in absorbing these nutrients (WEIH et al., 2021). Silva et al. (2014) found that Mg is the nutrient that most limits the growth of the BRS Platina cultivar, although, according to these authors, this cultivar has higher efficiency in the absorption of all macronutrients and higher Mg transport efficiency compared to 'Prata-Anã'.

The higher K mean and variance values observed for the BRS Platina cultivar compared to the Prata-Anã cultivar probably indicate greater demand by this cultivar for this nutrient; that is, 'BRS Platina' would have a greater nutritional requirement for this nutrient compared to 'Prata-Anã.' According to Silva et al. (2014), seedlings from the 'BRS Platina' (AAAB) tetraploid hybrid have higher macronutrient absorption and transport efficiency than their progenitor, 'Prata-Anã' (AAB) triploid. In general, there is great variation in nutrient contents, especially micronutrients, which may have influenced yield.

The higher frequencies of statistical differences between means than between variances and between bivariate ratios (DRIS indices) than between nutrient contents (BIK indices) analyzed in this study corroborate results obtained by Rodrigues Filho et al. (2021a). However, the frequencies of statistical differences reported by these authors were higher, probably because they compared norms established for different locations (Ceará and Bahia) using cultivars of contrasting genomic groups (Prata-Anã and Grande Naine). According to Mourão Filho (2004), variances of bivariate ratios are lower in HYP than in LYP.

Regarding the nutrient absorption efficiency for BRS Platina and Prata-Anã cultivars, Silva et al. (2014) observed that, when cultivated in nutrient solution with the omission of each macronutrient, 'BRS Platina' seedlings were more efficient in K, Mg and S absorption, while 'Prata-Anã' seedlings were more efficient in N, P and Ca absorption. Therefore, the ratio between these nutrients is important, especially because K and N are the macronutrients most accumulated and exported by banana plants (DEUS et al., 2020).

In general, the frequency of statistical differences between cultivars, for both BIK and DRIS norms, can be considered high, mainly for the means of DRIS indices and because cultivars are progenitors and progeny with similar yields in four successive production cycles, differing only between cycles (Marques et al., 2022), which can be justified by differences in absorption, transport and nutrient use efficiency (SILVA et al., 2014; SOUZA et al., 2016). This reinforces the statement of Rodrigues Filho et al. (2021a) about limitations in the extrapolations of norms, which should be established specifically for each cultivar, whether they are progenitor or progeny.

Rodrigues Filho et al. (2021a) observed greater variability between norms established for 'Prata-Anã' than for 'Grande Naine' in different regions (Ceará and Bahia). They also explained that the high frequency of significantly different regional norms may be related to soil and climate differences. However, in the present study, carried out in the same region and under the same cultivation and management conditions, the differences between norms may be exclusively related to cultivars, especially regarding different nutrient requirements. These results corroborate those obtained by Silva et al. (2014) and Souza et al. (2016) with banana plants in the seedling stage, as well as those by Hoffmann et al. (2010b) with banana plants in the production stage for cultivars of the same Prata subgroup.

Regarding the contrast between cultivars in the distribution of samples in HYP as a function of fertilization with different K_2O doses, it could be inferred that, due to the highly improved soil fertility, the concentration of nutrients in the absorption curve of the Prata-Anã cultivar may be under the condition of luxury accumulation, since the increase in the contribution of fertilized plots for the high-yield population does not accompany the increase in the supply of nutrients. That is, a higher number of high-yield plots was observed in treatment without fertilization with fertilizers for organic management, possibly due to the higher K recovery rate, already high in the soil, by plots that did not receive fertilization (LÉDO et al., 2021).

Marques et al. (2022) observed that the application of different doses of fertilizers for organic management in improved fertility soils promoted luxury consumption conditions for N, P, Ca and Mg for more than one cultivation cycle. This was confirmed by the similarity in yields between cultivars at different fertilization doses, varying only with the production cycle (MARQUES et al., 2018; 2022).

In the case of 'BRS Platina', the larger number of samples in HYP with the increase in nutrient supply may be related to differences in the efficiencies of absorption, transport and nutrient use efficiency compared to 'Prata-Anã'.

According to Silva et al. (2014), 'BRS Platina' banana seedlings showed higher absorption efficiency of all macronutrients than their progenitor, 'Prata-Anã', when evaluated in a complete nutrient solution, although both have the same transport efficiency, except in the omission of Mg, with a higher value for progeny, and increase the nutrient use efficiency under the omission of P, K, Ca, Mg and S, compared to adequately nourished plants.

In any case, these results reinforce the assumption that Prata banana genotypes cultivated under the same edaphoclimatic and management conditions may differ regarding nutritional needs and, therefore, regarding nutritional status interpretative norms, which should be specific.

5. CONCLUSIONS

Kenworthy and DRIS norms show variability among cultivars and are higher for BRS Platina than for Prata-Anã.

Kenworthy norms in the high-yielding population differ by 33.00%. In comparison, DRIS norms differ in about 70.00% of the cases between 'Prata-Anã' and 'BRS Platina,' pointing to the lower similarity in DRIS indices.

The Kenworthy and DRIS norms established support the specific nutritional diagnosis of 'Prata-Anã' and 'BRS Platina' banana plants grown in soils with improved fertility.

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Data availability: The corresponding author can obtain study data by e-mail.

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