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Reference values for nutritional diagnosis of 'Gigante' cactus pear by boundary line approach

Abstract – The objective of this work was to determine reference values for nutritional diagnosis of 'Gigante' cactus pear cultivated with organic fertilization under semi-arid conditions by boundary line approach. The contents of nutrients, determined in samples collected in newly mature cladodes, dry matter yield (DMY), and nutrient extraction of 72 plots of an experiment with 'Gigante' cactus pear, fertilized with cattle manure, were used to establish the reference values. The lower (L_l) and upper (L_u) limits of the reference values were determined by fitted regression of DMY (y) as a function of nutrient contents in cladodes (x), considering a percentage of the maximum dry matter yield (slope = 0). The reference values, established by boundary line approach for macronutrients and micronutrients, are accurate for the nutritional diagnosis of 'Gigante' cactus pear and determine classes for interpretation of nutritional status. The normal reference values established for macronutrients, in g kg^{-1}, are: N (≤11.2 – <19.0), P (≤1.0 – <2.1), K (≤26.7 – <44.2), S (≤0.9 – <2.1), Ca (≤22.1 – <32.6), and Mg (≤9.1 – <13.0); and micronutrients, in mg kg^{-1}, are: B (≤21.6 – <33.5), Cu (≤1.7 – <4.8), Fe (≤49.0 – <125.4), Mn (≤0.0 – <680.4), Zn (≤28.3 – <80.6), and Na (≤19.3 – <72.2).

Index terms: *Opuntia ficus-indica*, macronutrient, micronutrient, organic fertilization, semi-arid.

Valores de referência para diagnose nutricional da palma-forrageira 'Gigante' pelo método da linha de fronteira

Resumo – O objetivo deste trabalho foi determinar valores de referência para diagnose nutricional da palma-forrageira 'Gigante' cultivada com adubação orgânica em condições semiáridas pelo método da linha de fronteira. Os teores de nutrientes, determinados em amostras coletadas em cladódios recém-maduros, a produtividade de matéria seca (PMS) e a extração de nutrientes de 72 parcelas de um experimento com palma-forrageira 'Gigante', adubada com matéria orgânica, foram utilizadas para estabelecer os valores de referência. Os limites inferior (L_i) e superior (L_s) dos valores de referência foram determinados por regressão ajustada da PMS (y) em função dos teores de nutrientes nos cladódios (x), considerando uma porcentagem da máxima produtividade de matéria seca (declividade = 0). Os valores de referência, estabelecidos pelo método da linha de fronteira para macronutrientes e micronutrientes, são precisos no diagnóstico nutricional da palma-forrageira 'Gigante' e determinam as classes de interpretação dos estados nutricionais. Os valores de referência adequados estabelecidos para macronutrientes, em g kg^{-1}), são: N (≤11.2 – <19.0), P (≤1.0 – <2.1), K (≤26.7 – <44.2), S (≤0.9 – <2.1), Ca (≤22.1 – <32.6) e Mg (≤9.1 – <13.0); e micronutrientes, em mg kg^{-1}, são: B (≤21.6 – <33.5), Cu (≤1.7 – <4.8), Fe (≤49.0 – <125.4), Mn (≤0.0 – <680.4), Zn (≤28.3 – <80.6), and Na (≤19.3 – <72.2).

Termos para indexação: *Opuntia ficus-indica,* macronutriente, micronutriente, fertilização orgânica, semiárido.

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Introduction

Cactus pear (*Opuntia ficus-indica* Mill.) is adapted to the adverse conditions of the semi-arid region due to its morphological and physiological characteristics, which confer tolerance to long periods of drought and ensure high water use efficiency (Donato et al., 2014a). The crop represents a viable solution for feeding herds during dry periods due to its good dry matter production per hectare, high content of non-fibrous carbohydrates, good acceptability, digestibility, and energy value. In addition, its fruits, flowers, and seeds contain several groups of bioactive compounds with antioxidants, antimicrobial, anticancer, among other activities (Tahir et al., 2019). Brazil produces 2.87 million tons of the crop, with Bahia being the largest producing state, accounting for 45% of the production, among the four most important crops in the state (IBGE, 2017).

The production potential of cactus pear is maximal when adequate nutrient ratios promote normal development of the crop, consequently, knowing the nutritional balance and equilibrium of plants is important to evaluate the yield potential and the need for fertilization (Hernández-Vidal et al., 2021). Leaf diagnosis is used to complement soil chemical analysis, and visual diagnosis reflects the dynamics of nutrients in the soil-plant system, which contributes to a sustainable and economically viable cultivation (Donato et al., 2017b). Leaf concentration of nutrients is currently considered the most pertinent and reliable method to assess the nutritional status of plants because it represents the in situ condition holistically, although several methods have shown the dynamic nature of nutrient composition in plant tissue (Attar & Joolka, 2015).

The boundary line approach has been used as an alternative to conventional methods of nutritional diagnosis in spite of its limitations due to the strong influence of plant organ age (Bhat & Sujatha, 2013). It was developed to establish relationships between two variables measured under field conditions, in which the dependent variable is limited by more than one variable (Lafond, 2013). According to the method, the line that defines the best performance of the population is at the edge of any body of data and occurs whenever there is a cause-effect relationship between two variables, excluding the interference of environmental factors, represented by the points below that line.

The boundary line approach, used to obtain optimal concentrations and reference values for nutritional diagnosis of crops, predicts the relationship between nutrient content and yield and allows determining, for both commercial crop fields and experimental design, the optimal ratios between nutrients in plant tissue, besides allowing the estimation of the maximum production for any data set (Almeida et al., 2016).

Studies that determined reference values for cactus pear by nutritional diagnosis methods are scarce. Blanco-Macías et al. (2009, 2010) determined sufficiency ranges for the crop by Compositional Nutrient Diagnosis (CND) and boundary line approach methods for the edaphoclimatic conditions of Mexico; Teixeira et al. (2019) established Diagnosis and Recommendation Integrated System (DRIS) standards; Alves et al. (2019a, 2019b) established interpretative standards for nutrient contents in cladodes by Mathematical Chance (MCh) and Sufficiency Range methods; Donato et al. (2017b) found the chemical attributes of soil cultivated with 'Gigante' cactus pear by the methods of Sufficiency Range and Critical Level by reduced normal distribution (NCRIz) under semi-arid conditions in Bahia; Hernández-Vidal et al. (2021) defined optimal contents for N, P, K, Ca, and Mg, without determining classes for nutritional evaluation of the crop under Mexican conditions; and Teixeira et al. (2021) determined the reference values for nutritional diagnosis of the crop by DRIS and Balanced Indexes of Kenworthy (BIK) methods.

The objective of this work was to determine reference values for nutritional diagnosis of 'Gigante' cactus pear cultivated with organic fertilization under semi-arid conditions by boundary line approach.

Materials and Methods

The experiment with 'Gigante' cactus pear genotype was conducted in the municipality of Guanambi, state of Bahia, Brazil (14°13'30"S, 42°46'53"W, at an altitude of 525 m) in a soil classified as Latossolo Vermelho-Amarelo, according to the Brazilian Soil Classification System (Santos et al., 2018), which corresponds to an Oxisol (Soil Survey Staff, 2014). According to Köppen-Geiger's classification, the predominant climate in this region is BSwh, a hot Caatinga climate with summer rains and a well-defined dry period. The annual rainfall average is 680 mm and the temperature average is 26°C at the study site.

Donato et al. (2014a, 2014b, 2016, 2017a) and Barros et al. (2016) data were used to establish the reference values of the study. Contents of the macronutrients: N, P, K, S, Ca, and Mg, and the micronutrients: B, Cu, Fe, Mn, Zn, and Na were determined in samples collected in newly mature cladodes, dry matter yield (DMY) and nutrient extraction of 72 plots of an experiment with 'Gigante' cactus pear, fertilized with cattle manure, whose average DMY was 19.93 Mg ha^{-1} per cycle.

As suggested by Bhat & Sujatha (2013) and Ali (2018), the regression curve was determined with the selected points, located in the upper boundary region of the data dispersion. The maximum contents were determined by solving the first derivative of the regression equation: 2ax + b = 0, where the nutrient contents in the cladodes were used as independent variables (x) and dry matter yield as a dependent variable (y).

The lower limit (L_l) and the upper limit (L_u) of each class of the reference values were determined by solving the regression equations for the nutrient content in the cladodes, considering a percentage of the maximum dry matter yield (slope = 0). Five classes were established: deficient, DMY < 70%, to the left of the maximum; low, 70% ≤ DMY < 90%, to the left of the maximum; normal, 90%, to the left of the maximum, ≤ DMY < 90%, to the right of the maximum; high, 90% > DMY ≥ 70%, to the right of the maximum; and excessive, DMY > 70%, to the right of the maximum, as described by Rodrigues Filho et al. (2021) and Santos et al. (2022). The optimal ratios between nutrients were calculated in a similar way to the reference values for nutrients, solving the first derivative of the regression equation: 2ax + b = 0, where the optimal ratio in the cladodes were used as independent variables (x) and dry matter yield as a dependent variable (y).

Results and Discussion

For 'Gigante' cactus pear cultivated with organic fertilization under semi-arid conditions of Bahia, regression equations were fitted between the nutrient content in the cladode and DMY using different numbers of points located in the upper boundary region of the data dispersion. Five (N, B, and Na), six (K, S, Fe and Zn), seven (Ca and Cu), nine (Mg and Mn) and 11 (P) points were used. The fitted models were significant quadratic, except for N, B, and Na, and showed medium to high values of R^2 (0.75 to 0.97) for all nutrients (Table 1).

Table 1. Regression equation, number of points used in regression (n), coefficient of determination (R^2), optimal content (OC), and dry matter yield (DMY) for the optimal nutrient content in cladodes of 'Gigante' cactus pear (*Opuntia fícus-indica*), in the municipality of Guanambi, in the state of Bahia, Brazil.

Macronutrient	Regression equation	n	R^2	Optimal content (g kg^{-1})	DMY (Mg ha^{-1} per cycle)
N	$DMY = -18.274 + 7.366^{ns}N - 0.2436^{ns}N^2$	5	0.95	15.12	37.42
P	$DMY = 9.3754 + 35.225^{**}P - 11.532^{**}P^2$	11	0.86	1.53	36.27
K	$DMY = -24.523 + 3.525^{*}K - 0.0497^{*}K^2$	6	0.90	35.46	37.98
S	$DMY = 13.136 + 30.809^{**}S - 10.481^{**}S^2$	6	0.96	1.47	35.78
Ca	$DMY = -64.087 + 7.3805^{*}Ca - 0.1348^{*}Ca^2$	7	0.76	27.38	36.94
Mg	$DMY = -79.038 + 20.975^{**}Mg - 0.9473^{**}Mg^2$	9	0.93	11.07	37.07
Micronutrient	Regression equation	n	R^2	Optimal content (mg kg^{-1})	DMY (Mg ha^{-1} per cycle)
B	$DMY = -43.268 + 5.9011^{ns}B - 0.107^{ns}B^2$	5	0.75	27.58	38.09
Cu	$DMY = 19.358 + 9.9902^{**}Cu - 1.5273^{**}Cu^2$	7	0.95	3.27	35.69
Fe	$DMY = 16.09 + 0.4009^{*}Fe - 0.0023^{*}Fe^2$	6	0.88	87.15	33.56
Mn	$DMY = 32.041 + 0.0202^{*}Mn - 0.00003^{**}Mn^2$	9	0.97	336.67	35.44
Zn	$DMY = 20.071 + 0.5665^{*}Zn - 0.005^{*}Zn^2$	6	0.84	54.47	35.50
Na	$DMY = 25.076 + 0.4668^{ns}Na - 0.0051^{ns}Na^2$	5	0.86	45.76	35.76

* and ** Significant by T-test, at 1% and 5% probability, respectively. ^{ns} Nonsignificant.

The ideal strategy in crop management is to keep the nutrient content either at or as close as possible to the optimal point. According to the optimal nutrient content in cladodes of 'Gigante' cactus pear, the order of concentration of macronutrients is K > Ca > N > Mg > P > S. The values of optimal concentrations are close to those found by Hernández-Vidal et al. (2021) for Ca (36.65 g kg^{-1}), K (35.18 g kg^{-1}) and Mg (13.83 g kg^{-1}), higher for N (10.20 g kg^{-1}) and half for P (3.04 g kg^{-1}) in fruiting cladodes. These variations in concentrations occur because cladodes play an important role in the translocation of nutrients to the new cladodes and fruits. Blanco-Macías et al. (2010) also stated that K and Ca are the nutrients with the highest concentrations in cladodes. The micronutrients in order of concentration indicated by the optimal content is Mn > Fe > Zn > Na > B > Cu.

The ratios between nutrients of greatest importance for 'Gigante' cactus pear were determined considering the supply of nutrients by organic matter. The optimal ratios, estimated through boundary line approach, with high values of R^2 (0.76 to 0.99), are presented in Table 2. Four (K/N, N/S, N/B, Mn/B), six (N/P, Ca/N, S/B), eight (Ca/Mg, P/S) and nine (P/B) points were used to fit the regression equations between the nutrient ratio in the cladode and DMY. The optimal ratios for N/P, K/N, Ca/N, Ca/Mg, P/S, N/S, N/B, P/B, S/B, and Mn/B were 13.55, 2.36, 1.81, 2.63, 0.89, 10.11, 0.53, 0.05, 0.06, and 14.64, respectively.

Teixeira et al. (2019), through the DRIS method, found for the same ratios and their respective values: 13.23 for N/P, 2.5 for K/N, 1.85 for Ca/N, 2.42 for Ca/Mg, 0.92 for P/S, 11.49 for N/S, 0.59 for N/B, 0.05 for P/B, 0.06 for S/B, and 13.36 for Mn/B in the high-yield population; and 13.54 for N/P, 2.46 for K/N, 2.16 for Ca/N, 2.53 for Ca/Mg, 0.94 for P/S, 11.38 for N/S, 0.54 for N/B, 0.05 for P/B, 0.05 for S/B, and 18.70 for Mn/B in the low-yield population, demonstrating agreement between nutritional diagnosis methods to obtain optimal ratios between nutrients. Blanco-Macías et al. (2010) found for the K/N and Ca/N ratios the values of 3.4 and 2.9, respectively, suggesting that cactus pear tends to accumulate more K and Ca than N in the cladodes.

Ratios between nutrients in plants have been used as indicators of nutritional balance, consequently, variations in these ratios lead to nutritional imbalance and reductions in growth and yield. Mainly the ratios between micronutrients must be maintained at optimal levels, since wide variation results in a considerable reduction in yield (Bhat & Sujatha, 2013).

The regression equations resulting from the relationship between the nutrient contents in the cladodes and the dry matter yield (Table 1) were used to establish the reference values for the nutrient content in 'Gigante' cactus pear cladodes (Table 3), which were decomposed into five classes for nutritional evaluation.

Although the regression equation was nonsignificant for N (Table 1), the limits of deficient and excessive classes of the reference values obtained by the boundary line approach were close to those proposed by Alves et al. (2019a) through the Sufficiency Range

Table 2. Regression equation for the ratio between nutrients, number of points used in regression (n), coefficient of determination (R^2), optimal ratio (OR), and dry matter yield (DMY) for the optimal ratio among nutrients in cladodes of 'Gigante' cactus pear (*Opuntia ficus-indica*), in the municipality of Guanambi, in the state of Bahia, Brazil.

Ratio	Regression equation	n	R^2	Optimal ratio	DMY (Mg ha^{-1} per cycle)
N/P	$DMY = 26.944 + 1.019^{ns}N/P – 0.0376^{*}N/P^2$	6	0.89	13.55	33.85
K/N	$DMY = 7.5881 + 24.273^{ns}K/N – 5.137^{ns}K/N^2$	4	0.91	2.36	36.26
Ca/N	$DMY = - 0.1892 + 39.729^{*}Ca/N – 10.977^{*}Ca/N^2$	6	0.95	1.81	35.76
Ca/Mg	$DMY = - 63.715 + 74.005^{**}Ca/Mg – 14.063^{**}Ca/Mg^2$	8	0.98	2.63	33.65
P/S	$DMY = - 75.608 + 253.98^{**}P/S – 143.42^{**}P/S^2$	8	0.92	0.89	36.83
N/S	$DMY = 31.07 + 0.7382^{ns}N/S – 0.0365^{ns}N/S^2$	4	0.76	10.11	34.80
N/B	$DMY = 17.874 + 74.269^{ns}N/B – 69.604^{ns}N/B^2$	4	0.98	0.53	37.69
P/B	$DMY = 10.082 + 861.93^{**}P/B – 7923.9^{**}P/B^2$	9	0.95	0.05	33.52
S/B	$DMY = -1.1834 +1269.5^{**}S/B – 10947^{**}S/B^2$	6	0.99	0.06	35.62
Mn/B	$DMY = 31.55 + 0.4363^{ns}Mn/B – 0.0149^{ns}Mn/B^2$	4	0.99	14.64	34.74

* and **Significant by T-test, at 1% and 5% probability, respectively. ^{ns}Nonsignificant.

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technique for other macronutrients. In this context, the amplitudes of the values are similar, indicating that any reference values can be used to accurately identify plots with nutritional deficiency or excess. The amplitude of the reference values for macronutrients obtained by the boundary line is greater than those obtained by Teixeira et al. (2021) through the DRIS method, more indicated for nutritional evaluation of macronutrients than the BIK method, due to the lower amplitude in the limits of the reference values. These differences are associated with the conception of each method (Rodrigues Filho et al., 2021), because the basic data are the same.

The reference values defined by boundary line approach can be lower, equal, or higher than those found in the BIK method, showing that the methods determine the extent of reference values differently (Rodrigues Filho et al., 2021). When the range is wide, the possibility of obtaining the nutrient content in the cladode of a sample within this range is very high. On the other hand, when the range is narrow, this possibility decreases and the result is more accurate (Guimarães et al., 2015).

Although the sufficiency ranges proposed by Blanco-Macías et al. (2010) and Hernández-Vidal et al. (2021) are narrower for some macronutrients, such as N, K, and Ca, the authors did not determine values for S, micronutrients, and nutritional status classes. Donato et al. (2017b) attributed the differences between the ranges they found and those reported by Blanco-Macías et al. (2010) to local edaphoclimatic conditions, using soil with twice organic matter and K contents, two and a half times of P, 11 times of Ca and five times of Mg. In addition, the highest rates of K recovery by cactus pear occur under organic fertilization, which adds the lowest amounts of K to the soil compared to mineral fertilization (Lédo et al., 2021). However, the differences are also justified by the methods used, since Blanco-Macías et al. (2010) established the optimal concentrations considering a yield of 95%, differently from the present study.

There was a greater input of P and S by organic matter, since cattle manure was used to fertilize the soil. In addition, the critical level of P in the soil varies with the capacity of adsorption of the element by the soil. According to Donato et al. (2014a), the doses of cattle manure positively influenced the P content in cladode tissues, regardless of spacing. Donato et al. (2016), in soil with 16.3 mg dm^{-3} P, found contents of 1.3 and 1.7 g kg^{-1}, without and with application of 30 Mg ha^{-1} of manure, respectively, and 2.0 and 2.5 g kg^{-1} with applications of 60 and 90 Mg ha^{-1}, respectively. There was also an increase in the remaining P, from 41.8 to 45.0 mg dm^{-3}, with 0 and 90 Mg ha^{-1} of cattle manure. This higher availability of P in the soil increases its content in cladode tissues beyond the

Table 3. Reference values for nutritional diagnosis of 'Gigante' cactus pear (*Opuntia fícus-indica*) determined using the boundary line approach, in the municipality of Guanambi, in the state of Bahia, Brazil.

Nutrient	Reference value				
	Deficient(1) (DMY < 70%)	Low(1) (70% ≤ DMY < 90%)	Normal(1) (90% ≤ DMY < 90%)	High (90% > DMY ≥ 70%)	Excessive (DMY > 70%)
Macronutrient					
N (g kg^{-1})	< 8.3	8.3 - 11.2	11.2 - 19.0	19.0 - 21.9	≥ 21.9
P (g kg^{-1})	< 0.6	0.6 - 1.0	1.0 - 2.1	2.1 - 2.5	≥ 2.5
K (g kg^{-1})	< 20.3	20.3 - 26.7	26.7 - 44.2	44.2 - 50.6	≥ 50.6
S (g kg^{-1})	< 0.5	0.5 - 0.9	0.9 - 2.1	2.1 - 2.5	≥ 2.5
Ca (g kg^{-1})	< 18.3	18.3 - 22.1	22.1 - 32.6	32.6 - 36.4	≥ 36.4
Mg (g kg^{-1})	< 7.6	7.6 - 9.1	9.1 - 13.0	13.0 - 14.5	≥ 14.5
Micronutrient					
B (mg kg^{-1})	< 17.2	17.2 - 21.6	21.6 - 33.5	33.5 - 37.9	≥ 37.9
Cu (mg kg^{-1})	< 0.6	0.6 - 1.7	1.7 - 4.8	4.8 - 5.9	≥ 5.9
Fe (mg kg^{-1})	< 21.0	21.0 - 49.0	49.0 - 125.4	125.4 - 153.3	≥ 153.3
Mn (mg kg^{-1})	< 0.0	0.0 - 0.0	0.0 - 680.4	680.4 - 932.0	≥ 932.0
Zn (mg kg^{-1})	< 9.2	9.2 - 28.3	28.3 - 80.6	80.6 - 99.7	≥ 99.7
Na (mg kg^{-1})	< 0.0	0.0 - 19.3	19.3 - 72.2	72.2 - 91.6	≥ 91.6

(1)Negative values were replaced with zero.

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sufficiency range, which can characterize luxury consumption. At the same time, P is a macronutrient of low export in dry matter by cactus pear, 2.1 kg Mg^{-1} and low response to application (Donato et al., 2017b).

Organic fertilization promotes greater availability and mobility of P in the soil, compared with chemical fertilizers, however, regardless of the source used, P absorption by the plant was favored by higher fertilizer doses. In this study, P extraction was equal to 1.3 kg Mg^{-1}. Due to insufficient Ca supply by organic fertilization, the buffering capacity of the soil maintained cactus pear yield. Depending on the production cycle and on the source used, Ca is one of the most exported elements by cactus pear (Lédo et al., 2021).

The reference values, determined by the boundary line, considered the micronutrient Mn in the deficient class up to the lower limit of the normal class, and Na in the deficient class at the lower limit of the low class, assuming negative values. Alves et al. (2019b), studying nutrient contents in cladodes, and Donato et al. (2017b), assessing nutrient contents in the soil, used a correction factor to reduce the amplitude of the range for the cases of nutrients with high variability, which is very common for micronutrients in tissues, with CVs above 20%, which contributed to narrowing the ranges. Although Teixeira et al. (2021) found different limits of the reference values for micronutrients, according to the BIK method, the amplitude is not discrepant from those determined by boundary line approach, enabling the use of one of the methods in nutritional assessment with the same efficiency.

Alves et al. (2019a, 2019b) used the NCRIz method to determine the critical contents of nutrients in cladodes. The NCRIz values for N (14.4 g kg^{-1}), K (31.9 g kg^{-1}), S (1.1 g kg^{-1}), Ca (24.6 g kg^{-1}), Mg (10.2 g kg^{-1}), B (23.7 mg kg^{-1}), Fe (62.0 mg kg^{-1}), Mn (111.0 mg kg^{-1}), Zn (30.3 mg kg^{-1}), and Na (19.4 mg kg^{-1}) are within the normal class, and the value for Cu (1.6 mg kg^{-1}) is within the low class, and the value for P (1.0 g kg^{-1}) is at the limit between low and normal classes determined by the boundary line. Although the authors used the average dry matter yield + 0.5 standard deviation to separate the high and low-yield plots, different from that in the present study, the NCRIz values reinforce that the reference values established by the boundary line approach can be used for the interpretation and diagnosis of nutritional status, considering the exceptions for micronutrients.

Cladode size is determined by genotypic factors and, to a lesser extent, by phenotypic factors related to the production system and to climatic interferences (Matos et al., 2020), which reinforces that, for more accurate interpretive diagnoses and crop management, it is essential to consider the interactions between nutrients and site, as well as soil and climate conditions (Donato et al., 2017a). These interactions influence the flow of nutrients in the soil-plant system, consequently, even with very well established norms, different environments require different managements (Resende et al., 2017).

Conclusions

1. The reference values, established by boundary line approach for macronutrients and micronutrients, are accurate for the nutritional diagnosis of 'Gigante' cactus pear (*Opuntia ficus-indica*) and determine classes for interpretation of nutritional status.

2. The normal reference values determined by the boundary line approach for macronutrients, in g kg^{-1}, are: N (≤11.2 – <19.0), P (≤1.0 – <2.1), K (≤26.7 – <44.2), S (≤0.9 – <2.1), Ca (≤22.1 – <32.6), and Mg (≤9.1 – <13.0); and micronutrients, in mg kg^{-1}, are: B (≤21.6 – <33.5), Cu (≤1.7 – <4.8), Fe (≤49.0 – <125.4), Mn (≤0.0 – <680.4), Zn (≤28.3 – <80.6), and Na (≤19.3 – <72.2).

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