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Original article

Integrated diagnosis and ranges of nutrients in the soil for the cultivation of beans (*Phaseolus vulgaris*) in Cerrado region

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ABSTRACT

The Integrated Diagnostic and Recommendation System (DRIS), although is commonly used in the interpretation of leaf analyzes, has been little used in soil chemical analysis. The corrective and fertilizer recommendations for the Cerrado region developed for the conventional cultivation system based on calibration studies, without including the current technological advances. In this sense, the objective was to establish the integrated diagnosis and nutrient ranges in soils under bean cultivation (*P. vulgaris*) in this region. Soil samples collected at the depth of 0-20 cm, having values of organic matter, Ca, Mg, K, P, S, Zn, B, Cu, Fe, Mn, base saturation and cation exchange capacity at pH 7. Ground rules DRIS standards and sufficiency ranges were established from farming with productivity equal to and greater than 2700 kg ha^{-1} of beans and these became applicable for recommendation fertilization of this crop in the region. Most established parameters presented discrepancy in relation to the theoretical framework that currently has for the region. DRIS standards and ranges should be regional and specific to direct seeding for high yield crops.

Key words: *Phaseolus vulgaris*, nutrients, chemical analysis

INTRODUCTION

From the 80s of the twentieth century, there was a significant technological change in the bean crop, with the implementation and expansion of irrigated areas in several Brazilian states, especially in the Midwest region, due to it is a short-cycle crop with high expectations of economic return that often grown as a winter crop. In the region of Goiás, traditionally from May to July it is sown, replaced by sweet corn and tomato crops in the composition of the annual harvest [(1)].

The correct interpretation of the chemical analyzes of the soil is important to indicate the sources, quantities and the most appropriate time for the application of corrective and fertilizers by the producer. To calibrate a method in soil analysis is to relate the content of the element in the soil, with the characteristics of the plant (growth rates, yield and nutrient content in crops) grown in the field [(1)].

According to research [(1–3)], sufficiency ranges are the most widely used method for interpreting soil and leaf analysis, since it considers a concentration range below which the growth rate or production decreases. According to this author [(3)], the nutrient balance , a concept advocated in the Integrated Diagnostic and Recommendation System (DRIS) for foliar analysis , can also be used for the soil, which increases the interpretation options of the analyzes soil chemicals . These techniques, although commonly used for the interpretation of leaf analysis, have been used in the analysis of soil in coffee (*Coffea canephora*) [(3)], banana (*Musa* spp) [(4)], orange (*Citrus sinensis*) [(5,6)], cotton (*Gossypium hirsutum*) [(7)] and sugarcane (*Saccharum officinarum*) [(8)].

The DRIS seeks to assess the nutritional status of the plant, with the evaluation of nutrient two in two, as an appropriate way to express the physiological and metabolic events that take place throughout the cycle working with external factors reflected in the foliar nutrients.

The recommendations for the Goiás state of corrective and fertilizers for the conventional culture system are based on outdated calibration studies (1960-1980). However, significant changes in production systems have been introduced in recent years, especially the migration of many of the grain areas such as soy a (*Glycine max*), corn (*Zea mays*) and beans (*Phaseolus vulgaris*) for the direct sowing system and many more productive varieties are launched [(2)].

Studies also indicate that the norms must be regional, including standards for soil, since the climatic conditions, fertility, as well as the technological level are different in Brazil and in the world. This scenario implies the need for new regional benchmarks that include the technological advances experienced in the period. In this regard, it was proposed to establish the integrated diagnosis and nutrient ranges in soils under bean cultivation (*P. vulgaris*) in the Cerrado region.

MATERIALS AND METHODS

The study was conducted in commercial fields in a micro region of Goiás state called Vale do Rio dos Bois. This region comprises nine districts, namely: Palmeiras de Goiás, Turvâni, Campestre de Goiás, Cezarina, Edéia, Indiara, Paraúna, Palminópolis and Jandaia. The region has two distinct seasons, one scarce rain and low temperatures and other hot and humid, with precipitation annual average of 1250 mm. According to the classification of Koppen climate it is type tropical, with a dry season in winter (Aw). The predominant soil is classified as Amarelo Distrófico (Ferralsol-Word Reference Base For Soil) (9), with mean fertility and pH acid around 5.0. Flat reliefs predominate on the surface, with good drainage conditions, favoring the use of mechanization, allowing cultivation in large areas (10).

The type of irrigation used was central pivot, representative of the region under study. In all evaluated areas, the variety planted was perola, group the bean is bays and tillage system with application of herbicides in areas previously infested with invasive plants mainly constituted by *Urochloa brizantha*. The separation used varied from 0.45 to 0.5 m, with planting densities ranging from 12 to 15 seeds per meter line , obtaining populations between 240 and 333 thousand plants per hectare.

For the generation of optimal ranges of nutrients and DRIS standards for soil they were monitored 28 commercial fields of bean crop of year 2010, and they were conducted soil analysis and identification of productivity, being selected 20 fields of high productivity equal to or greater than 2700 kg ha^{-1} (Table 1). The sowing was carried out from June to the beginning of August 2010, and the evaluations were carried out in the period between August and September of that year.

Table 1. Location and characteristics of the areas studied. Goiás, 2010

City	Latitude (South)	Longitude (West)	Height (m a.s.l)	Área (ha)	Textural Class	Production (kg ha^{-1})
Cezarina 1*	16º56`45``	49º`45`56``	594	53	Clayish	2.680
Cezarina 2	16º59`12``	49º44`13``	577	54	Clayish	2.930
Cezarina 3*	16º56`33``	49º`48`20``	613	63	Clayish	2.480
Campestre 1*	16º42`44``	49º38`22``	682	45	Clayish	2.670
Campestre 2*	16º59`12``	49º44`13``	577	54	Clayish	2.430
Edéia 1	17º27`08``	49º44`24``	614	68	Clayish	2.700
Edéia 2	17º27`08``	49º44`24``	614	68	Clayish	2.700
Edéia 3*	17º24`52``	49º47`20``	589	57	Sandy Clay	2.590
Indiara 1	17º07`33``	50º00`58``	551	35	Clayish	2.800
Indiara 2	17º06`03``	49º59`46``	565	53	Clayish	2.750
Palmeiras 1	16º50`16``	49º57`14``	590	83	Clayish	2.790
Palmeiras 2	16º54`29``	50º02`50``	568	49	Sandy Clay	3.005
Palmeiras 3*	16º48’58’’	49º58’54’’	603	78,5	Clayish	2.800
Palmeiras 4	16º42`34``	50º04`25``	674	48	Argylose	2.900
Palmeiras 5	16º46`03``	49º54`14``	666	50	Sandy Clay	2.870
Palmeiras 6	16º50`55``	49º50`49``	645	82	Clayish	2.760
Palmeiras 7	16º46`20``	49º54`51``	689	95	Clayish	2.890
Palmeiras 8	16º50`33``	49º51`19``	638	49	Clayish	2.900
Palmeiras 9	16º41`59``	49º57`23``	651	64	Clayish	3.120
Palmeiras 10*	16º53`54``	49º51`00``	656	35	Clayish	2.660
Palmeiras 11*	16º52`02``	49º57`54``	589	117	Clayish	2.490
Palmeiras 12*	16º50`33``	49º51`19``	638	49	Clayish	2.390
Palmeiras 13*	16º54`20``	50º02`29``	548	50	Clayish	2.500
Paraúna 1	16º59`10``	50º21`41``	594	78	Clayish	2.760
Paraúna 2	17º16’40’’	50º22’25’’	629	79	Clayish	2.725
Paraúna 3	17º06’21’’	50º23’18’’	618	50	Clayish	2.700
Paraúna 4	17º48’28’’	50º24’29’’	670	34	Clayish	2.780
Paraúna 5	16º59`22``	50º23`33``	622	95	Clayish	2.700

*Areas discarded from standards due to producing less than 2700 k g ha^{-1} and not to present normal distribution

These fields were divided into four quadrants for performance evaluation was assumed to repeat each of the four quadrants occupied by the irrigation system and these repetitions of normality was verified data 80 simple samples in each pivot (per quadrant 20) were taken to a depth of 0-2 0 cm to form a composite sample being sent for analysis at the laboratory Solocria located in Goiânia in Goiás state. In the composition of each individual sample three sub-samples were taken, one in the rows of crops and the other between the rows, according recommendations made in other studies [(11)].

Sampling the soil is carried out in the period where the beans at the stage of development characterized as R5 (beginning of flowering). The samples were placed in plastic bags and they were sent to the laboratory. It is determined ran macro and micronutrients, cation exchange capacity (CEC), base saturation (V) and the organic matter content according to the described methodology [(12)].

Database was created, with the concentration of nutrients in the soil, crop separating high productivity (less than 2.700 kg ha^{-1} bean). This value was chosen because it is considered high for that region of Goiás State, and can be used as a reference of high productivity and technological level. The Lilliefors test was applied, at the level of 1 % probability, to verify the normality of the values referring to the contents of each nutrient of the group of high productivity fruits [(2)].

Agricultural soils, which showed a productivity equal or exceeding 2.700 kg ha^{-1} and whose concentrations of nutrients present normal distribution, were used to establish the DRIS standards soil (mean, standard deviation and coefficient of variation) and bands (average more or less standard deviation). After this procedure is separately calculated ratios of nutrients, being selected 20 crops for the rules after the test of normality.

Comparisons were made between the basic rules established with beans from other regions. In addition, it is nutritional diagnosis of crops used in standards for other levels described in the literature made.

RESULTS AND DISCUSSION

The relationships between two soil nutrients (Table 2), the deviation and the coefficient of average variation give credibility to the diagnosis of soil fertility by DRIS in bean crops in the study area.

Table 2. Average ratio of nutrients (Average), standard deviation (DE) and coefficient of variation (CV) of winter bean crops with high yield in the micro region of the Bois - Goiás river valley

Ratio	Means	DE	CV(%)	Ratio	Mean	DE	CV(%)
MO/P	2.356	1.172	49.73	Cu/MO	0.099	0.067	67.28
MO/K	0.202	0.069	34.05	Cu/P	0.181	0.049	26.85
MO/Ca	10.68	3.557	33.29	Cu/K	0.017	0.006	34.41
MO/Mg	38.21	15.26	39.95	Cu/Ca	0.899	0.315	35.08
MO/S	1.840	0.752	40.86	Cu/Mg	3.375	1.643	48.68
MO/B	177.12	67.91	38.34	Cu/S	0.165	0.086	52.46
MO/Cu	13.47	6.335	47.01	Cu/B	15.05	6.040	40.12
MO/Fe	0.872	0.288	33.07	Cu/Fe	0.075	0.029	38.15
MO/Mn	1.586	0.726	45.76	Cu/Mn	0.140	0.066	47.37
MO/Zn	7.582	5.911	77.96	Cu/Zn	0.537	0.164	30.56
MO/V	0.434	0.118	27.21	Cu/V	0.037	0.013	35.97
MO/CEC	4.274	1.263	29.56	Cu/T	0.368	0.141	38.45
P/MO	0.560	0.374	66.73	Fe/MO	1.301	0.537	41.28
P/K	0.097	0.029	29.85	Fe/P	2.888	1.932	66.91
P/Ca	5.142	1.661	32.31	Fe/K	0.233	0.036	15.59
P/Mg	19.10	8.294	43.42	Fe/Ca	12.91	4.953	38.37
P/S	0.912	0.423	46.43	Fe/Mg	44.77	13.13	29.32
P/B	86.17	32.73	37.99	Fe/S	2.305	1.211	52.55
P/Cu	5.881	1.424	24.21	Fe/B	206.7	55.79	27.00
P/Fe	0.430	0.146	34.03	Fe/Cu	15.91	7.772	48.86
P/Mn	0.803	0.364	45.36	Fe/Mn	1.821	0.498	27.33
P/Zn	3.145	1.533	48.72	Fe/Zn	9.151	7.670	83.81
P/V	0.211	0.066	31.06	Fe/V	0.523	0.152	29.00
P/CEC	2.090	0.704	33.70	Fe/T	5.074	1.290	25.42
K/MO	5.724	2.654	46.37	Mn/MO	0.782	0.372	47.59
K/P	11.96	6.172	51.63	Mn/P	1.841	1.465	79.60
K/Ca	54.61	13.87	25.39	Mn/K	0.143	0.068	47.15
K/Mg	192.3	48.87	25.41	Mn/Ca	7.760	3.808	49.07
K/S	9.866	4.434	44.94	Mn/Mg	24.79	4.110	16.58
K/B	896.2	240.8	26.87	Mn/S	1.423	0.892	62.70
K/Cu	66.52	23.87	35.88	Mn/B	120.4	40.015	33.25
K/Fe	4.392	0.708	16.11	Mn/Cu	10.26	7.552	73.58
K/Mn	7.945	2.328	29.30	Mn/Fe	0.619	0.286	46.25
K/Zn	37.11	24.34	65.57	Mn/Zn	6.139	6.121	99.71
K/V	2.229	0.402	18.06	Mn/V	0.312	0.124	39.69
K/CEC	21.74	3.724	17.13	Mn/T	2.979	0.959	32.20
Ca/MO	0.106	0.043	40.56	Zn/MO	0.198	0.131	65.95
Ca/P	0.222	0.101	45.62	Zn/P	0.356	0.097	27.11
Ca/K	0.019	0.004	20.96	Zn/K	0.034	0.013	37.03
Ca/Mg	3.642	1.038	28.49	Zn/Ca	1.788	0.644	36.00
Ca/S	0.186	0.087	46.77	Zn/Mg	6.918	3.373	48.76
Ca/B	17.14	5.354	31.24	Zn/S	0.322	0.170	52.86
Ca/Cu	1.247	0.440	35.31	Zn/B	31.36	15.53	49.53

Ca/Fe	0.085	0.022	25.37	Zn/Cu	2.025	0.603	29.76
Ca/Mn	0.152	0.053	34.73	Zn/Fe	0.153	0.065	42.10
Ca/Zn	0.674	0.364	53.92	Zn/Mn	0.292	0.150	51.26
Ca/V	0.042	0.006	13.79	Zn/V	0.074	0.027	36.59
Ca/CEC	0.408	0.064	15.79	Zn/T	0.743	0.305	40.98
Mg/MO	0.032	0.016	48.96	V/MO	2.525	0.905	35.84
Mg/P	0.071	0.048	67.74	V/P	5.339	2.188	40.97
Mg/K	0.006	0.002	42.01	V/K	0.462	0.079	17.20
Mg/Ca	0.309	0.134	43.38	V/Ca	24.46	3.542	14.48
Mg/S	0.056	0.029	52.20	V/Mg	87.36	23.80	27.24
Mg/B	4.872	1.326	27.23	V/S	4.372	1.612	36.87
Mg/Cu	0.406	0.278	68.38	V/B	407.6	108.2	26.55
Mg/Fe	0.025	0.011	43.83	V/Cu	30.32	10.72	35.36
Mg/Mn	0.041	0.007	16.01	V/Fe	2.030	0.439	21.63
Mg/Zn	0.235	0.211	89.85	V/Mn	3.638	1.205	33.14
Mg/V	0.012	0.004	33.96	V/Zn	16.52	9.385	56.83
Mg/CEC	0.119	0.030	24.85	V/T	9.825	1.204	12.25
S/MO	0.624	0.228	36.48	T/MO	0.262	0.106	40.57
S/P	1.351	0.665	49.19	T/P	0.558	0.263	47.20
S/K	0.121	0.051	42.63	T/K	0.047	0.009	19.25
S/Ca	6.418	2.693	41.95	T/Ca	2.525	0.522	20.68
S/Mg	23.37	13.00	55.63	T/Mg	8.806	1.881	21.36
S/B	106.9	57.63	53.90	T/S	0.451	0.168	37.37
S/Cu	7.968	4.447	55.82	T/B	41.416	9.222	22.27
S/Fe	0.525	0.222	42.32	T/Cu	3.158	1.304	41.28
S/Mn	0.987	0.623	63.11	T/Fe	0.208	0.046	22.26
S/Zn	4.143	2.446	59.05	T/Mn	0.366	0.103	28.13
S/V	0.258	0.091	35.29	T/Zn	1.755	1.123	63.99
S/CEC	2.541	1.016	39.97	T/V	0.103	0.013	12.37
B/MO	0.0067	0.0031	47.21				
B/P	0.0142	0.0077	54.33				
B/K	0.0012	0.0003	27.08				
B/Ca	0.0650	0.0232	35.74				
B/Mg	0.2205	0.0614	27.83				
B/S	0.0114	0.0046	40.12				
B/Cu	0.0799	0.0390	48.84				
B/Fe	0.0052	0.0015	28.53				
B/Mn	0.0090	0.0025	27.32				
B/Zn	0.0458	0.0338	73.86				
B/V	0.0026	0.0007	26.07				
B/CEC	0.0254	0.0058	22.88				

V % = base saturation; MO = Organic Matter; CEC = cation exchange capacity at pH 7

The ranges established for the soil (Table 3) can be used to make the diagnosis of fertility in bean crops in the region of the Bois River Valley, Goiás State, as they were established based on representative crops of the region with high productivity.

Table 3. Average concentration of nutrient soil, standard deviation (SD), proficient range (FS) and the coefficient of variation (CV) of crops bean harvest winter with high performance in the micro region of the river valley Bois-Goiás

Nutrients	Concentration	SD	Sufficiency range	CV (%)
Organic matter (g/dm^3)	25.20	6.56	18.64 – 31.76	26.02
P (mg dm^{-3})	12.36	3.85	8.51 - 16.21	31.17
K (mg dm^{-3})	129.05	18.24	110.81 - 147.29	14.13
Ca (cmol$_c$ dm^3)	2.44	0.39	2.05 - 2.82	16.00
Mg (cmol$_c$ dm^3)	0.73	0.26	0.47 - 0.99	35.86
S (mg dm^{-3})	14.98	5.22	9.76 - 20.2	34.87
B (mg dm^{-3})	0.15	0.04	0.11 - 0.19	25.13
Cu (mg dm^{-3})	2.18	0.80	1.38 - 2.97	36.75
Fe (mg dm^{-3})	29.98	6.27	23.71 - 36.25	20.91
Mn (mg dm^{-3})	18.11	7.05	11.06 - 25.15	38.94
Zn (mg dm^{-3})	4.37	1.68	2.68 - 6.05	38.55
Sat. Bases (%)	58.36	4.28	54.08 - 62.64	7.34
CEC (cmol$_c$ dm^3)	6.01	0.71	5.29 - 6.72	11.87

V % = base saturation; MO = Organic Matter; CEC = cation exchange capacity at pH 7

The classes of interpretation of the chemical properties of the soil according to the proposed classification [13,14] are presented in Table 4.

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Table 4. Classes of interpretation of the chemical properties of the soil according to the proposed classification

Variable	Classes of Interpretation				
	Very low	Low	Moderate	Adequate	High
MO (g dm^{-3})[1]	-	<24.0	24.0-30.0	31.0-45.0	>45.0
P (mg dm^{-3})[1]	0.0-3.0	3.1-5.0	5.1-8.0	8.1-12.0	>12.0
P (mg dm^{-3})[2]	0.0-3.0	3.1-6.0	6.1-8.0	-	>8.0
K (mg dm^{-3})[1]	-	<26.0	26.0-50.0	51.0-80.0	>80.0
K (mg dm^{-3})[2]	-	<25.0	25.0-50.0	-	>50.0
Ca ($cmol_c dm^{-3}$)[1]	-	<1.5	1.5-7.0	-	>7.0
Ca ($cmol_c dm^{-3}$)[2]	-	<2.0	2.0-5.0	-	>5.0
Mg ($cmol_c$ dm^{-3})[1]	-	<0.5	0.5-2.0	-	>2.0
Mg ($cmol_c$ dm^{-3})[2]	-	<0.4	0.4-1.2		>1.2
S (mg dm^{-3})[1]	-	<4.0	4.0-9.0	-	>10.0
B (mg dm^{-3})[1]	-	<0.2	0.2-0.5	-	>0.5
Cu (mg dm^{-3})[1]	-	<0.4	0.4-0.8	-	>0.8
Fe (mg dm^{-3})[1]	-	<0.5	0.5-12.0	-	>12.0
Mn (mg dm^{-3})[1]	-	<2.0	2.0-5.0	-	>5.0
Zn (mg dm^{-3})[1]	-	<1.0	1.0-1.6	-	>1.6
V %[1]	-	<20.0	20.0-35.0	36.0-60.0	>60.0
CIC ($cmol_c dm^{-3}$)[1]	-	<7.2	7.2-9.0	9.1-13	>13.0

[1](13) y [2](14); V % = base saturation; MO = Organic Matter; CEC = cation exchange capacity at pH 7

The average concentration of organic matter (Table 3) is classified as moderate, based on this work and other studies (13,14) (Table 4). In most areas cultivated in soil, it is expected that the values of this variable actually submit higher value, because the soil favors the accumulation of the organic matter (MO) (15-17). Even average values of MO, in the areas considered showed high productivity, reaching up to 3, 120 kg ha^{-1} (Table 1). Other authors affirm that the stability of the MO in the soil is more important than its quantity itself (10) that it may be related to species grown in rotation and the high availability of water under the pivot.

The mean content 12.36 mg dm^{-1} and phosphorus (P) is classified as high (13,14) (Table 4). One of the main differences between conventional culture system and direct sowing is that the last one provoke the superficial concentration and subsuperficial of P, K, MO and other nutrients, as a result of fertilization cycle of nutrients, less mobilization of these nutrients in the soil and the reduction of erosion losses. Thus, the methodology used for the withdrawal of the samples would detect a greater value in the result of the soil analysis of these nutrients (16).

In recent years, there has been an increase in the use of natural phosphates as fertilizers, especially in soils cultivated in the direct sowing system. The Mehlich method used by most of soil analysis laboratories consists on dilute solution of concentrated acids whose reaction with natural phosphate is intense, could also overestimate the amount of available P [11].

The calibration of extractants for evaluation of phosphorus in the soil shows that this classified in below category to the required needs of plant [17]. Interactive methods of nutritional analysis involving evaluating soil fertility and DRIS could help in this case, as it has a great ability to diagnose subtle imbalances of nutrients. The calibration of other extractants should be considered especially if they have high coefficients of correlation between levels available in the soil, foliar concentration and productivity.

The concentration of potassium (K) is classified as high [13,14] (Table 3). In this case, a surface concentration of the element may have occurred. For K, it is worth mentioning the importance in the cycle of the return and maintenance of this nutrient in the soil. The exposure of this nutrient is about 2 % of the production. Taking into account the average production of the region under study, the export value of K_2O reaches 50 kg ha^{-1}, lower than what is often related to beans, around 60 kg of K_2O ha^{-1}. However, leaching losses must also be taken into account.

The calcium concentration (Ca) (Table 3) verified in the study areas is classified as moderate [13,14] (Table 4), although it appears in the lower limit class proposed by the authors. In the extension of the evaluation to other areas of the country, there is a tendency to classify the values found as moderate. According to data for Pará state, values are also classified as moderate (1.6 to 4.5 cmolc dm^{-3}) [18]. Other authors classify the content of Ca as moderate between 2.0 to 4.0-cmolc dm^{-3} [19]. In another investigation, the levels found were classified as high, although in the lower limit of the class (higher than 2.4 cmolc dm^{-3}) [20].

According to some authors, the average concentration of magnesium (Mg) (Table 3) is classified as moderate [13,14,18,20] (Table 4).

The sulfur concentration (Table 3) is considered high [13,14] (Table 4). Even the sulfur has a mobile character on the ground, tends to focus on the cap as subsurface, and this fact favors the surface concentration of phosphorus also should take into account the frequent fertilizations with plaster adopted as common practice by the local farmers and fertilizers with ammonium sulfate that helps maintain high levels of this nutrient.

With regard to the micronutrients only the B (Table 4) was classified as low [13,14]. Other micronutrients (Zn, Cu, Fe and Mn) are presented in the range considered as suitable to high, according to the authors.

Base saturation (V=58.36 %) is considered adequate for beans [13], in line with high yields. However, the cation exchange capacity at pH 7 (T=6.01) is considered low by the same authors.

Soil chemical characteristics, precipitation and associated with suitable temperatures, can provide high productivities [2,18], made found in areas used as references in the present work.

Studies also indicate that the rules must be regional [2–4,10], including standards for soil, since the climatic conditions, fertility, as well as the technological level are different in Brazil and in the world. The differences recorded between the norms of other regions and the differences in the form of final (conventional vs. direct sowing) of Goiás state, support the assertion that the rules must be regional, for the specific form of cultivation and adapted to high yields

Values of P, K, Mg, S, Cu, Mn, Fe and Zn in this study were classified respectively as adequate or excessive in the 100 % of the cases (Table 5). However, the 85 and 100 % of B were considered low [13,14].

CONCLUSIONS

- DRIS standards and adequacy ranges established the cultivated soils under direct seeding with bean irrigated in region closed.
- The DRIS standards and sufficiency ranges are applicable to the recommendation of fertilizers in soils cultivated under direct sowing with irrigated beans in the closed region. Besides its amount, it is important to their interrelationships.
- The values of P, K, Mg, S, Cu, Mn, Fe and Z n were classified as adequate or excessive in 100 % of the samples. However, more than 85 % of the content of the B samples were considered low.

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