DRIS norms for evaluating the nutritional state of pea plants

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Abstract: The Diagnosis and Recommendation Integrated System (DRIS) is an alternative to these traditional approaches. It relates to the nutrient contents in dual ratios, enabling the evaluation of the nutritional balance of a plant, ranking the nutrient levels in relative order from the most deficient to the most excessive. DRIS was developed to incorporate the importance of nutrient balance into plant analyses. DRIS norms were established from a data bank of a leaf nutrient concentration (N, P, K, Fe, Mn, Zn and Cu) and grain yield with 45samples. DRIS norms were calculated using two criteria for the choice of the ratio order of nutrients (F value- ratio of the variance of the relationships among nutrients between the reference group and the low productivity group, and R value- correlation coefficients between the productivity values and relationship between pairs of nutrients). The selected DRIS norms were P/N: 2.941, K/N: 3.133, Fe/N: 686.2, Mn/N: 63.22, Zn/N: 74.42, Cu/N: 77.03, P/K: 0.940, Fe/P: 233.8, Mn/P: 21.67, P/Zn: 0.041, P/Cu: 0.039, Fe/K: 215.7, K/Mn: 0.054, K/Zn: 0.045, K/Cu: 0.042, Fe/Mn: 11.20, Fe/Zn: 9.769, Fe/Cu: 9.161, Zn/Mn: 1.235, Cu/Mn:1.315, Zn/Cu: 0.979.The DRIS norms for P, K, Mn, Zn and Cu with high F value (s^2_l/s^2_h ratio)and low coefficient of variation (CV) found in current research probably can provide more security to evaluate the P, K, Mn, Zn and Cu status of pea plants. Data from future surveys and field experiments may subsequently be used to enlarge the database allowing the refinement of model parameters and hopefully an expansion of the diagnostic scope such as to include other nutrients.

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Introduction

Green peas stand out as an environmentally friendly food. Peas belong to a category of crops called "nitrogen fixing" crops. With the help of bacteria in the soil, peas and other pulse crops are able to take nitrogen gas from the air and convert it into more complex and usable forms. This process increases nitrogen available in the soil without the need for fertilizer addition. Peas also have a relatively shallow root system which can help prevent erosion of the soil, and once the peas have been picked, the plant remainders tend to break down relatively easily for soil replenishment. Rotation of peas with other crops has been shown to lower the risk of pest problem.

The Diagnosis and Recommendation Integrated System (DRIS) has been used as a concept for assessment of tissue nutrient level and subsequent diagnosis of excesses, adequacies and deficiencies byBeaufils since seventieth of 20th century. **Elwali and Gascho (1984)** based upon using a large number of observations on nutrient concentrations and yield, obtained accurate estimates of means and variances of certain ratios of nutrients that discriminate between high- and low- yielding subpopulations. The mean and coefficients of variations of DRIS reference parameters in the high- yielding subpopulation are then used in a special calibration formula for diagnostic purposes. **Savoy and Robinson (1990)** reported that use of a norm rang for the calculation of DRIS to diagnose a balanced nutrient status in white clover grown on the relatively in fertile providence soil.

In the calculations of the DRIS method only one type of relationship is used for each pair of nutrients. Several criteria to select the most appropriate relation have been proposed. **Bataglia and Santos (1990)** evaluated the relations among nutrients in the direct order and in the inverse order and they concluded that the order of relation could interfere in the results of calculation for the citrus indices of nutrients, especially if the functions are obtained by method of **jones (1981)**.

One of the most commonly used criteria to select the relationship among nutrients is the criterion of the highest relation of variances between the populations of low productivity and the populations of high productivity – "F value" **(Letzsch, 1985; Walworth and Summer, 1987)**. **Nick (1998)** proposed the criterion called "R value" to choose the ratio order of nutrients in the application DRIS for trimmed coffee plants. The ratio order is chosen according to the result in the highest absolute value of the correlation coefficient (r) among the values of the response variable of the plant and the ratio between pairs of nutrients.

The objective of this work was establishment appropriate norms for the pea crop in Shalakan, Kalubia governorate (middle of Delta), seeking to use the DRIS method for its nutritional diagnosis.

2. Materials and Methods

A total of 15 pea fields were sampled during the 2012 season from Shalakan (Kalubia governorate), Egypt. Some physical and chemical properties of the cultivated soil were evaluated in sampled in the same season according to standard procedures reported by **Jackson (1973)** to be then presented in (Table, 1).

Table (1): Some physical and chemical properties of thecultivated soil.

Soil property	Value	Soil property	Value
Particle size distribution %		pH (1:2.5 soil suspension)	8.10
Sand	21.6	EC (dS m^{-1}), soil paste extract	2.11
Silt	28.5	Soluble ions (mmol L^{-1})	
Clay	49.9	Ca^{++}	3.59
Texture	Sandy clay loam	Mg^{++}	1.19
$CaCO_3$ %	1.92	Na^+	11.4
Organic matter%	1.50	K^+	4.94
Available N (mg kg^{-1})	155	CO_3^{--}	nd
Available P (mg kg^{-1})	6.03	HCO_3^-	1.69
Available K (mg kg^{-1})	280	Cl^-	8.97
		SO_4^{--}	10.4

nd: not detected

Pea pods yield data and 45 leaf samples were collected in commercial pea fields. Yield and nutrient concentrations established a databank, which was divided into high- (≥5.28 ton ha^{-1}) and low- yield (<5.28 ton ha^{-1}) populations. Leaf samples were dried at 65C° for 48 hrs, ground and wet digested using mixture of H_2SO_4: H_2O_2 method **(Cottenie, 1980)**. The digests were then subjected to measurement of N using Micro-Kjeldahle method; P was assayed using molybdenum blue method; K was determined by Flame Photometer**(Chapman and Pratt, 1961)**, while Fe, Zn and Mn were determined using atomic absorption spectrophotometer**(Cottenie*et al*., 1982)**.

In order to establish the DRIS norms, it is necessary to use a representative value of leaf nutrient concentrations and respective yields to obtain accurate estimates of means and variances of certain nutrient ratios that discriminate between high- and low yielding groups. Pair of nutrient ratios is calculated from the data bank of nutrient concentrations and then, the mean, the variance and the coefficient of variation of each ratio are calculated. There are two forms of expression for a pair of nutrients, although in DRIS calculations only one form is used **(Walworth and Sumner (1987) and Hartz*et al*., 1998).**

To choose the ratio order of nutrients two criteria were used. The first, proposed by **Nick (1998)**, called "R value", consists of the calculation of the correlation coefficients (r) among the productivity values and the relationship between pairs of nutrients, either in the direct order or in the inverse order. The order of the relationship that presents the larger absolute value of the correlation coefficient (r) is selected:

if: [r A/B] > [r B/A] then: relationship in the norm = A/B

if: [r A/B] < [r B/A] then: relationship in the norm = B/A

where: [r A/B] = absolute value of the correlation coefficient between the productivity and the ratio among the concentrations of the nutrients A and B of the population; [r B/A] = same as above for nutrients B and A.

The second criterion, described by **Letzsch (1985)** and **Walworth and Sumner (1987)**,called "F value", consists of the calculation of the ratio of variance of the relationships among nutrients between the reference group (a) and the one of low productivity (b), either in the direct order or in the inverse order. It is selected the order of relationship that presents the larger variance ratio between the high and the low productivity groups:

if: $[s^2 (A/B)_b / s^2 (A/B)_a] > [s^2 (B/A)_b / s^2 (B/A)_a]$ then: relationship in the norm = A/B

if: $[s^2 (A/B)_b / s^2 (A/B)_a] < [s^2 (B/A)_b / s^2 (B/A)_a]$ then: relationship in the norm = B/A

where: $s^2 (A/B)_a$ = variance of the ratio among the concentrations of the nutrients A and B of the reference population (a); $s^2 (A/B)_b$= same for nutrients A and B of the population of low productivity (b); $s^2 (B/A)_a$ = same for nutrients B and A of (a); $s^2 (B/A)_b$ = same for nutrients B and A of (b).

3. Results and Discussions

Summary statistics for the pod yield and leaf nutrients concentration of peaplant data are given in Table (2). The yield data ranged from 4.82 ton ha^{-1} to 7.87 ton ha^{-1} with a mean of 6.563 ton ha^{-1} in the full population. Thirty two out of 45 data points were assigned to the high yielding subpopulation (≥5.28 ton ha^{-1}). As regards the leaf nutrient concentrations, the data for all the nutrients N, P, K, Fe, Mn, Zn and Cu were relatively symmetrical, because all nutrients having skewness values less than 1.0 and hence were deemed suitable for DRIS norms development.

Binary nutrient ratio combinations of all seven nutrients were therefore calculated, and summary statistics evaluated for each of the resulting 42 nutrient ratio expressions (Table 3).

Table 2.Summary statistics for pea yield and leaf nutrient concentration data for total (n=45) and high-yielding sub-populations (n= 32).

Parameters	Total population (n = 45)					High yielding sub-population (n = 32)					V (low/high)
	Mean	Median	Mini	Maxi	Skew	Mean	Median	Mini	Maxi	Skew	
Pod yield (ton ha^{-1})	6.56	6.66	4.82	7.87	-0.33	7.02	6.98	5.93	7.87	0.18	1.95
Nutrients (g kg^{-1})											
N	0.61	0.62	0.40	0.80	-0.32	0.61	0.63	0.40	0.80	-0.61	0.43
P	1.89	1.96	1.13	2.55	-0.58	1.76	1.66	1.13	2.55	0.81	0.14
K	1.91	1.91	1.16	2.29	-0.08	1.89	1.88	1.60	2.29	0.18	0.80
Nutrients (mg kg^{-1})											
Fe	413	401	100	671	0.28	402	400	100	670	0.05	0.31
Mn	38.3	36.3	15.0	64.8	0.49	37.7	35.0	15.0	64.0	0.65	1.10
Zn	45.5	45.1	25.0	83.2	0.09	45.7	45.2	25.0	83.0	0.11	1.04
Cu	47.6	45.2	30.0	81.0	0.59	46.5	42.8	30.0	81.0	0.01	0.74

Mini: Minimum; Maxi: Maximum; Skew: Skewness

Table 3. DRIS norms(average, coefficient of variation and standard deviation) and variance for the relationships between pairs of nutrients, correlation coefficient between the ratio of each pair of nutrients and the productivity of pea crop (R) and ratio between variances of populations of high and low productivity (F), considering the high productivity population

Ratio	Mean	CV	s	s^2	R	F	Ratio	Mean	CV	s	s^2	R	F
N/P	0,3590	24.42	0.088	0.008	-0.012	0.156	Cu/P	26.697	22.98	6.135	37.63	-0.132	0.751
P/N	2.9416	22.78	0.670	0.449	0.029	0.447	K/Fe	0.0057	59.83	0.003	$1*10^{-5}$	-0.164	0.055
N/K	0.3236	12.19	0.039	0.002	-0.025	1.326	Fe/K	215.70	36.79	79.35	6296.9	0.170	0.276
K/N	3.1339	12.13	0.380	0.144	-0.020	1.413	K/Mn	0.0549	35.07	0.019	0.004	0.107	1.474
N/Fe	0.0019	62.07	0.001	$1*10^{-6}$	-0.017	0.069	Mn/K	20.297	33.43	6.785	46.04	0.100	0.803
Fe/N	686.27	43.25	296.8	88114	0.113	0.224	K/Zn	0.0453	28.59	0.013	$1*10^{-4}$	0.058	0.822
N/Mn	0.0177	37.18	0.007	$4*10^{-5}$	-0.106	1.057	Zn /K	23.979	31.00	7.434	55.27	0.014	0.771
Mn/N	63.223	32.82	20.75	430.5	0.106	1.149	K/Cu	0.0426	21.43	0.009	$8*10^{-5}$	-0.109	1.104
N/Zn	0.0146	30.50	0.004	$2*10^{-5}$	-0.028	1.208	Cu/K	24.773	26.93	6.670	44.49	-0.118	0.679
Zn/N	74.425	28.63	21.31	454.0	0.049	1.931	Fe/Mn	11.206	43.43	4.867	23.69	0.081	0.880
N/Cu	0.0137	25.16	0.003	$1*10^{-5}$	-0.078	0.543	Mn/Fe	0.1066	42.72	0.045	0.002	-0.129	0.723
Cu/N	77.032	24.87	19.16	367.1	0.144	0.660	Fe/Zn	9.7695	49.66	4.581	23.53	0.054	0.642
P/K	0.9402	20.95	0.197	0.039	0.014	0.377	Zn /Fe	0.1337	53.75	0.072	0.005	-0.195	0.358
K/P	1.1092	20.54	0.227	0.052	-0.024	0.190	Fe/Cu	9.1610	43.54	3.989	15.91	0.101	0.433
P/Fe	0.0051	46.45	0.002	$6*10^{-6}$	-0.179	0.087	Cu/Fe	0.1403	61.05	0.086	0.007	-0.096	0.188
Fe/P	233.86	41.01	95.90	9196.4	0.176	0.096	Mn/Zn	0.8677	27.79	0.241	0.058	-0.093	2.475
P/Mn	0.0496	28.06	0.013	$2*10^{-4}$	-0.087	1.041	Zn/Mn	1.2352	25.96	0.321	0.103	-0.088	4.012
Mn/P	21.673	27.85	6.035	36.43	0.143	1.207	Mn/Cu	0.8369	30.58	0.256	0.065	-0.052	1.370
P/Zn	0.0411	22.59	0.009	$9*10^{-5}$	-0.024	3.378	Cu/Mn	1.3156	35.97	0.473	0.224	-0.026	4.187
Zn/P	25.683	25.14	6.457	41.70	-0.036	1.477	Zn /Cu	0.9792	22.96	0.225	0.051	-0.068	5.591
P/Cu	0.0390	18.05	0.007	$4*10^{-5}$	-0.082	2.172	Cu/Zn	1.0739	23.21	0.249	0.062	-0.059	2.289

DRIS norms were calculated using two criteria for the choice of the ratio order of nutrients (F value - ratio of the variance of the relationships among nutrients between the reference group and the low productivity group, and R value-correlation coefficients between the productivity values and relationship between pairs of nutrients). The selected DRIS norms were P/N: 2.941, K/N: 3.133, Fe/N: 686.2, Mn/N: 63.22, Zn/N: 74.42, Cu/N: 77.03, P/K: 0.940, Fe/P: 233.8, Mn/P: 21.67, P/Zn: 0.041, P/Cu: 0.039, Fe/K: 215.7, K/Mn: 0.054, K/Zn: 0.045, K/Cu: 0.042, Fe/Mn: 11.20, Fe/Zn: 9.769, Fe/Cu: 9.161, Zn/Mn: 1.235, Cu/Mn:1.315, Zn/Cu: 0.979.

Admittedly, the database used for the DRIS model development was relatively small. However, most of the nutrient content and yields of high and low–subpopulations were significantly different. This variation is a consequence of the source of data. All the data were gathered from different fields in the amounts and sources of fertilizers used in the process of fertilization, were soil nutrient availability changed due to fertilization treatments **(Gustave*et al*., 2011)**. According to **Reis and Monnerat (2003)**, those differences between nutritional status of high and low-yielding subpopulations are indicative or reliability of DRIS norms that will be developed. The DRIS norms for P, K, Mn, Zn and Cu with high F value (s^2_l/s^2_hratio) and low coefficient of variation (CV) found in this article probably can provide more security to evaluate the P, K, Mn, Zn and Cu status of pea plants. As pointed out by **bailey *et al*., (1997)**, DRIS norms (nutrient ratios) with large ratio of variance and small coefficient of variation imply that the balance between these specific pairs of nutrients could be of critical importance for crop production. Therefore, nutrient ratios with a large ratio of variance with a small coefficient of variation around the average nutrient ratio.

Data from future surveys and field experiments may subsequently be used to enlarge the database allowing the refinement of model parameters and hopefully an expansion of the diagnostic scope such as to include other nutrients.

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