Using Diagnosis and Recommendation Integrated System (DRIS) to Determine Nutrient Norms for Peanut Crop

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Abstract: The Diagnosis and Recommendation Integrated System (DRIS) approach evaluates plant nutritional status and based on a comparison of crop nutrient ratios with optimum values from a high yielding group (norms). The objective of this study was establish DRIS norms for peanut crop, to compare mean yield, nutrient contents of leaves and variance of nutrient ratios of low- and high- yielding groups. To carry out this research, ninety leaf samples were analyzed for N, P, K, Fe, Zn and Mn contents and respective yields were recorded of peanut fields from Ismailia governorate. The data were divided into high- yielding (≥ 12 ton ha^{-1}) and low- yielding (< 12 ton ha^{-1}) sub-population and the norms were computed using standard DRIS technique. The DRIS norms for K, Fe and Zn with high S^2_l/S^2_h ratio and low coefficient of variation (CV) found in this paper probably can provide more security to evaluate the K, Fe and Zn status of peanut.

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1. Introduction:

Plant analysis can be a useful tool for correcting plant nutrient deficiencies and imbalances **(Baldock & Schulte, 1996)**, optimizing crop production **(Walworth *et al.*, 1986)**, and for evaluating fertilizer requirements. The Diagnosis and Recommendation Integrated System (DRIS) is a recent approach to interpreting plant-tissue analyses. According to **Beaufils (1973)** and **Walworth and Sumner (1987)**, an alternative approach to nutritional status evaluation is the DRIS. This method uses a comparison of leaf tissue concentration ratios of nutrient pairs with norms developed from high-yielding populations to diagnose nutrient status. DRIS has been used successfully to interpret the results of foliar analyses for a wide range of crops such as rubber and sugarcane **(Elwali and Gascho 1984)**, cotton **(Dagbénonbakin *et al.*, 2009)**, mango **(Hundal *et al.*, 2005)** vegetables, potatoes, wheat **(Amundson and Koehler 1987; Meldal-Johnsen and Sumner, 1980)** and even forage grass **(Bailey *et al.*, 2000)**. The DRIS method has advantages over traditional methods for being based on nutritional ratios instead of average levels of each nutrient, eliminating dilution and concentration effects that are not dealt with adequately by traditional methods **(Dias, 2001)**.

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. This is done using a survey approach in which yield and nutrient concentration data are collected from commercial crops and/or field experiments from a large number of locations **(Bailey *et al.*, 1997a)** to form a databank.

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. The way to select the form of ratio for a pair of nutrients to be used in DRIS calculation is described by **Walworth and Sumner (1987)** and **Hartz *et al.*, (1998)**.

After the establishment of the DRIS norms, the formula proposed by **Beaufils (1973)** calculates an index for each nutrient that range from negative to positive values. All nutrient indices always sum to zero **(Elwali and Gascho, 1984)**. Essentially, a nutrient index is a mean of the deviations from the optimum or norms values **(Bailey *et al.*, 1997b)**. Negative DRIS index values indicate that the nutrient level is below optimum, consequently the more negative index refer to the more deficient of the nutrient. Similarly, a positive DRIS index indicates that the nutrient level is above the optimum, and the more positive index refer to the more excessive of nutrient, and DRIS index equal to zero indicates that the nutrient is at the optimum level **(Baldock and Schulte, 1996)**. The DRIS also computes an overall index, which is the sum of the absolute values of the nutrient indices called nutrient balance index (NBI) **(Rathfon and Burger, 1991)**.

The objectives of this study were to establish DRIS norms for peanut crop, to compare mean yield, leaves nutrient contents and variance of nutrient ratios of low- and high- yielding groups and to compare mean values of nutrient ratios selected as the DRIS norms of low- and high- yielding groups.

2. Material and Methods

Plant sampling and chemical analysis:

A total of 30 peanut fields were sampled during the 2011 season from Ismailia governorate, Egypt. Peanut yield data and ninety leaf samples were collected in commercial peanut fields. Peanut yield data were collected from sampled fields. Yield and foliar nutrient concentrations built a databank, which was divided into high- ($\geq$ 12 ton ha^{-1}) and low- yield (< 12 ton ha^{-1}) groups. Leaf samples were dried at 65C° for 48 hrs, ground and wet digested using H_2SO_4: H_2O_2 method **(Cottenie, 1980)**. The digests samples were then subjected to measurement of N using Micro-Kjeldahle method; P was assayed using molybdenum blue method and determined by spectrophotometer **(Chapman and Pratt, 1961)**; K was determined by Flame Photometer, while Fe, Zn and Mn were determined using atomic absorption spectrophotometer.

Development of DRIS norms and Data Analysis:

Nutrient concentration data DRIS norms and coefficients of variation (CVs) of the grain yield and leaf tissue were derived according to the procedure of **Walworth and Sumner (1987)**.

Mean values or norms for each nutrient expression together with their associated CVs and population of and variances were then calculated for the two sub-populations. The mean values in the high-yielding sub-population of fifteen expressions involving six nutrients (N, P, K, Fe, Zn and Mn) were ultimately chosen as the diagnostic norms for peanut. The selection was made among the following priorities. The first was to ensure that the leaf nutrient concentration data for the high-yielding sub-population were relatively symmetrical or unskewed, so that they provided realistic approximations of the likely range of interactive influence among the different nutrients involved in the crop productivity **(Ramakrishna *et al*., 2009)**. The second priority was to select nutrient ratio expressions that had relatively unskewed distributions in the high-yielding sub-population (skewness values < 1.0). The third priority was to select nutrient expressions for which the variance ratios (S low/S high) were relatively large (> 1.0), thereby maximizing the potential for such expressions to differentiate between 'healthy' and 'unhealthy plants ' **(Walworth and Sumner, 1987)**. The fourth priority was to select nutrient expressions which have a Gaussian distribution versus yield.

Descriptive statistics (means, variances, coefficient of variance) were determined for dry matter of grain yield, leaf nutrient concentration and nutrient ratio expression data using Minitab statistical software version 12.

3. Results and Discussion

DRIS norms established for peanut crop (Table, 1) should be useful to evaluate peanut nutritional status and to calibrate fertilizer programs, but they must be validated before peanut growers adopt them.

Peanut crops in 18 fields were ranked in the high-yielding population (yield $\geq$ 12 ton ha^{-1}), while 12 fields yielded < 12 ton ha^{-1}. The average yield in the high-yielding population was 13.42 ton ha^{-1}, while the average yield in the low-yielding population was 10.92 ton ha^{-1} (Table, 2). This difference was statistically significant ($P < 0.05$).

Although the absolute average foliar N, P, K, Fe, Zn and Mn concentrations were higher in the high-yielding population than in low-yielding population, only the mean foliar N, P and K concentrations were significantly higher ($P < 0.05$) in the high-yielding population than in the low-yielding population (Table, 2).

The mean, coefficient of variation, variance of all nutrient ratios of the high- (S^2_h) and low-yielding population (S^2_l) and the variance ratio between the low- and high- yielding population (S^2_l/S^2_h) ratio are shown in (Table, 1). The selection of a nutrient ratio as DRIS norms (i.e.: N/P or P/N) is indicated by the S^2_l/S^2_h ratio **(Hartz *et al*., 1998)**. The higher S^2_l/S^2_h ratio, the more specific the nutrient ratio must be in order to obtain a high yield (Payne *et al*., 1990). Some of the selected nutrients ratios showed a lower coefficient of variation (CV) than the other possible nutrient ratio for the same pair of nutrients (i.e.: $CV_{P/N}$ = 14.02% < $CV_{N/P}$ = 18.20%). Although **Beaufils (1973)** suggested that every parameter which shows a significant difference of variance ratio between the two populations under comparison (low- and high- yielding) should be used in DRIS, other researchers have adopted the ratio which maximized the variance ratio between the low- and high- yielding populations **(Snyder *et al*., 1989; Payne *et al*., 1990 and Hartz *et al*., 1998)**. The aim of this procedure is to determine the norms with the greatest predictive precision (**Caldwell *et al*., 1994**). The discrimination between nutritionally healthy and unhealthy plants is maximized when the ratio of variances of low- versus high- yielding populations is also maximized **(Abd El-Rheem, 2003)**. It was reported by **Bailey *et al*., (2000)**, DRIS norms (nutrient ratios) with large S^2_l/S^2_h ratios 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 large S^2_l/S^2_h ratio and small coefficient of variation indicate that the obtainment of high yield should be associated to small variation around the average nutrient ratio. The DRIS norms for K, Fe and Zn with high S^2_l/S^2_h ratio and low coefficient of variation (CV) found in this paper probably can provide more security to evaluate the K, Fe and Zn status of peanut. There is a speculation that the large S^2_l/S^2_h ratio and the small CV found for specific ratios between nutrients probably imply that the balance between these pairs of nutrients could be important to peanut production.

Table 1. Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding populations, the variance ratio (S^2_l/ S^2_h) and the selected ratios for peanut DRIS norms.

Nutrients ratios	High-yielding population			Low-yielding population			S^2_l/ S^2_h	Selected ratios
	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)		
N/P	11.47	18.20	4.355	11.67	3.082	0.129	0.029	
P/N	0.089	14.02	0.0002	0.086	3.350	0.00001	0.053	*
N/K	1.366	5.916	0.006	1.438	7.087	0.0104	1.590	*
K/N	0.734	5.861	0.0018	0.698	7.160	0.0025	1.348	
N/Fe	2.812	9.351	0.0691	2.749	7.343	0.041	0.590	
Fe/N	0.360	9.755	0.0012	0.367	7.816	0.0008	0.669	*
N/Zn	8.368	7.870	0.433	8.147	6.639	0.2925	0.674	
Zn/N	0.120	8.562	0.00011	0.123	7.116	0.0001	0.727	*
N/Mn	100.8	28.66	834.9	94.52	15.15	205.03	0.246	*
Mn/N	0.011	28.37	0.00001	0.011	13.95	0.000002	0.244	
P/K	0.122	16.95	0.00043	0.123	5.751	0.0001	0.117	*
K/P	8.443	20.47	2.9856	8.140	6.173	0.2525	0.085	
P/Fe	0.253	20.16	0.0026	0.236	9.348	0.00049	0.187	*
Fe/P	4.164	29.37	1.4957	4.265	9.604	0.1678	0.112	
P/Zn	0.752	19.51	0.0215	0.699	8.388	0.0034	0.160	*
Zn/P	1.396	28.73	0.1609	1.439	8.743	0.0158	0.098	
P/Mn	9.085	35.81	10.587	8.129	18.05	2.1521	0.203	
Mn/P	0.124	36.57	0.0021	0.126	17.16	0.00047	0.228	*
K/Fe	2.065	10.74	0.0492	1.924	13.05	0.063	1.282	
Fe/K	0.489	11.17	0.00299	0.527	13.44	0.005	1.677	*
K/Zn	6.141	9.017	0.3067	5.702	12.63	0.5186	1.691	
Zn/K	0.164	9.407	0.00024	0.177	13.14	0.0005	2.274	*
K/Mn	73.45	26.74	385.7	66.44	21.37	201.7	0.523	
Mn/K	0.014	25.78	0.00001	0.016	21.39	0.00001	0.798	*
Fe/Zn	2.980	3.189	0.0090	2.965	1.049	0.001	0.107	
Zn/Fe	0.336	3.291	0.00012	0.337	1.148	0.00002	0.123	*
Fe/Mn	35.66	23.75	71.760	34.29	10.18	12.18	0.170	*
Mn/Fe	0.029	28.39	0.0001	0.029	10.22	0.00001	0.127	
Zn/Mn	12.01	25.41	9.318	11.57	10.73	1.543	0.166	*
Mn/Zn	0.089	29.66	0.0007	0.087	10.81	0.0001	0.128	

Table 2. Mean, coefficient of variation (CV), variance and variance ratio between the low- and high yielding populations (S^2_l/S^2_h) of both yield and nutrient contents in the leaf dry matter of peanut at high- and low- yielding populations[(1)].

Variable	Population	Mean	CV (%)	Variance (S^2)	S^2_l/S^2_h
Yield (ton ha^{-1})	High	13.42**	5.716	0.102	0.343
	Low	10.92	4.125	0.035	
N (g kg^{-1})	High	1.796**	2.796	0.002	10.00
	Low	1.642	8.601	0.020	
P (g kg^{-1})	High	0.167**	6.629	0.0001	0.0001
	Low	0.139	8.705	0.0001	
K (g kg^{-1})	High	1.313**	5.446	0.005	5.600
	Low	1.135	14.77	0.028	
Fe (mg kg^{-1})	High	623.5**	6.360	1572.5	0.021
	Low	607.9	0.945	33.02	
Zn (mg kg^{-1})	High	210.0	3.498	53.95	0.277
	Low	204.0	1.894	14.92	
Mn (mg kg^{-1})	High	18.69	31.30	34.22	0.079
	Low	18.51	8.882	2.702	

[(1)] High- yield ≥ 12 ton ha^{-1}, low-yield < 12 ton ha^{-1}; mean yield and foliar nutrient contents of low- and high- yielding populations are significantly different at the 5% (**).

Data from future field and surveys experiment may subsequently be used to enlarge the model database and allow the refinement of DRIS parameters and hopefully an expansion of diagnostic scope to include other nutrients. As it stand, though, this preliminary DRIS model for peanut is one of the best diagnostic tools currently available for simultaneously evaluating the N, P, K, Fe, Zn and Mn status of peanut.

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