# Establishment of DRIS Indices for Corn Plants Grown on Sandy Soil

Youssef, R. A., Abd El-Rheem Kh. M. and Nesreen H. Abou-Baker

Soils and Water Use Dept., National Research Centre, Dokki, Giza, Egypt
Refatay@ gmail.com

**Abstract:** Nutritional diagnosis is an important tool for increasing quantity and quality of yield through efficient fertilization management. The Diagnosis and Recommendation Integrated System (DRIS) was developed to incorporate the importance of nutrient balance into plant analyses. Preliminary DRIS norms for corn were developed during 2012 growing season in Ismailia governorate. DRIS norms were established from a data bank of a leaf nutrient concentration (N, P, K, Ca and Mg) and grain yield with 216 samples. The data were divided into high-yielding (≥ 2.8 ton $fed^{-1}$) and low-yielding (< 2.8 ton $fed^{-1}$) sub-populations and norms were computed using standard DRIS procedures. Such calculated DRIS norms concluded different 10 binary nutrients balance ratios assuring and securing high grain yield of corn crop. Obtained norms for corn plants were P/N, K/N, Ca/N, Mg/N, K/P, Ca/P, P/Mg, K/Ca, K/Mg and Ca/Mg whose values were 0.20, 1.24, 0.40, 0.21, 6.33, 2.03, 0.99, 3.44, 6.34 and 1.96. DRIS indices appear to the $N_{200}P_{80}K_{60}$ and $N_{200}P_{60}K_{40}$ were the best treatment in order to achieve the maximum corn crop.

[Youssef, R. A., Abd El-Rheem Kh. M. and Nesreen H. Abou-Baker. **Establishment of DRIS Indices for Corn Plants Grown on Sandy Soil.** *Life Sci J* 2013;10(3):1016-1020] (ISSN: 1097-8135). http://www.lifesciencesite.com**.** 148

**Keywords:** DRIS indices, Corn, Yield, Nutrients content.

## 1. Introduction

The diagnosis and Recommendation Integrated System (DRIS) was developed as a mean to organize and interpret plant tissue analysis data. This system makes multiple two-way comparisons between the levels of various plant components and integrates these comparisons into a series of nutrient indices. Plant components can then be ranked with respect to their relative abundance in the plant tissue sample undergoing analysis. **Sumner (1977)** initiated a preliminary DRIS norm for N, P, K in soybean leaves to be useful in diagnosing and ordering the most limiting and excessive elements. In past practice, comparisons have been made only between those nutrients which are largely root supplied such as N, P, K, Mg, S, B, Cu, Zn and Mn, although the system may provide for comparisons with other factors as well. The DRIS system has been used to predict nutritional requirements of alfalfa, sugarcane, soybean, maize, sunflower, oat and wheat, as well as several non-agronomic crops **(Walworth *et al.*, 1986)**.

The diagnosis and Recommendation Integrated System has been used as a concept for assessment of tissue nutrient level and subsequent diagnosis of excesses, adequacies and deficiencies by Beaufils since seventieth of $20^{th}$ 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 range for the calculation of the DRIS indices increased the tendency of DRIS to diagnose a balanced nutrient status in white clover grown on the relatively infertile providence soil.

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.*, 1997)**. 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 **(Baldock and Schulte, 1996)**, called nutrient balance index (NBI) **(Rathfon and Burger, 1991)**. The smaller the absolute sum of all DRIS indices, the lesser the imbalance among nutrients **(Snyder and Kretschmer, 1987)**.

## 2. **Materials and Methods**

A field trial was successively conducted on a loamy sand soil at Ismailia Agricultural Research Station cultivated with corn (Zea mays L., cv Giza 10) at summer 2012. The experiment was carried out in a split plot design, with three replicates for each experimental unite. In each plot, three nitrogen levels (100, 150 and 200 kg N/fed) in the form of $NH_4$ $(SO_4)_2$ (20.6 % N) combining with three phosphorus levels (40, 60 and 80 kg $P_2O_5$/fed) in the form of superphosphate (15% $P_2O_5$) and two potassium levels (40 and 60 kg $K_2O$/ fed) in the form of potassium sulfate. Corn yield data were collected from each plot; The data were divided into high-yielding (≥ 2.8 ton $fed^{-1}$) and low-yielding (< 2.8 ton $fed^{-1}$) sub-populations, as well as 108 leaf samples were analyzed for N, P, K, Ca, and Mg contents to establish DRIS indices. Plant 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; K was determined by Flame Photometer, while Ca and Mg were determined using atomic absorption spectrophotometer**(Chapman and Pratt, 1961)**.

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. 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 calculates an index for each nutrient that range from negative to positive values. DRIS indices may then be calculated for nutrients A to N using the following generalized equations **(Bailey *et al*., 1997; Hallmark *et al*., 1987)**:

$X \text{ index} = [f(X/A) + f(X/B) + \cdots - f(M/X) - f(N/X) - \cdots]$

Where $f(X/A) = 100\ [(X/A)/\ (x/a)]/\ CV$ when $X/A > x/a + SD$

and $f(X/A) = 100\ [1-\ (x/a)/\ (X/A)]/\ CV$ when $X/A < x/a - SD$.

X/A is the ratio of concentrations of nutrients X and A in the sample while x/a, CV, SD are the mean, coefficient of variation and standard deviation for parameter X/A in the high-yielding population, respectively. Similarly, other nutrient ratios X/B, M/X and N/X are calibrated against the corresponding DRIS reference parameters, x/b, m/b and n/x. Nutrient indices calculated by this formula can range from negative to positive values depending on whether a nutrient is relatively insufficient or excessive with respect to all other nutrients considered.

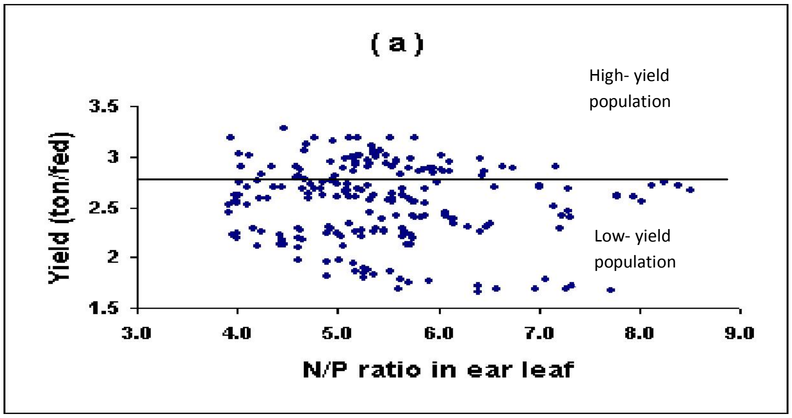
The objectives of this study were to establish DRIS indices for corn crop to choice the best fertilization formula to obtain maximum yield of corn crop.

## **3. Results and Discussion**

Corn grain yields were subdivided into two groups. The first is representing the high yielding population (H) having not less than 80% from the obtained relative yield. The second, however, is representing the low yielding population (L) having less than 80% from the obtained relative yield. Mean values of each nutrient expression together with their associated CVs and variances ($V_H$ and $V_L$) were then calculated for the two populations. In making the selection of the norms, there were two priorities: The first was to ensure that norms were based on Gaussian distribution of yield versus nutrient expression values (Fig, 1). Otherwise, calculated norms (means) for nutrient expression might differ from the true values at maximum crop yield **(Walworth and Summer, 1986)**. The second priority was to select nutrient expressions for which the variance ratios ($V_L$/ $V_H$) were relatively large, there by maximizing the potential for such expressions to differentiate between healthy and unhealthy plants **(Walworth and Summer, 1987)**.

Mean values of nutrient expressions for both populations, together with their respective CVs and variance, were calculated and shown in (Table, 1). A total of 10 nutrient ratio expressions were finally selected.

Obtained norms for corn plants were P/N, K/N, Ca/N, Mg/N, K/P, Ca/P, P/Mg, K/Ca, K/Mg and Ca/Mg whose values were 0.20, 1.24, 0.40, 0.21, 6.33, 2.03, 0.99, 3.44, 6.34 and 1.96. The selection of a nutrient ratio as DRIS norms (i.e.: N/P or P/N) is indicated by the variance ratio **(Hartz *et al*., 1998)**. The higher variance ratio, the more specific the nutrient ratio must be in order to obtain a high yield **(Payne *et al*., 1990)**. Although **Beaufils (1973)** suggested that every parameter which showed 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 **(Payne *et al*., 1990 and Hundal *et al*., 2005)**.



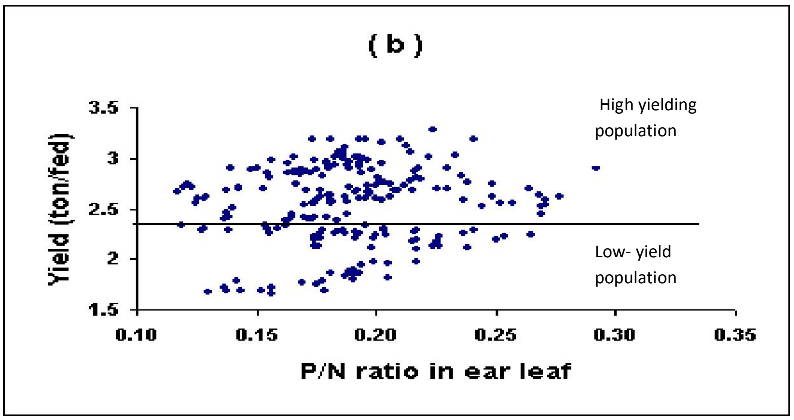




Fig (1): Scatter diagram showing (a) a non –Gaussian distribution of yield versus the N/P ratio in corn plant and (b) a Gaussian distribution of yield versus the (reciprocal) P/N in corn plant.

Table (1): Mean, coefficient of variation (CV) and variance ($V^2$) of nutrient ratios of the low- and high-yielding populations, the variance ratio ($V^2_L/V^2_H$) and the selected ratios for corn DRIS norms.

| Nutrients ratios | Low-yielding population | | | High -yielding population | | | $V^2_l/V^2_h$ | Selected ratios |
|---|---|---|---|---|---|---|---|---|
| | Mean | CV (%) | Variance ($V^2_L$) | Mean | CV (%) | Variance ($V^2_H$) | | |
| N/P | 0.19 | 19.4 | 0.001 | 0.20 | 25.5 | 0.003 | 0.33 | |
| P/N | 5.55 | 19.2 | 1.14 | 5.36 | 21.5 | 1.32 | 0.86 | √ |
| N/K | 0.90 | 28.9 | 0.07 | 1.24 | 40.6 | 0.26 | 0.27 | |
| K/N | 1.18 | 21.6 | 0.07 | 0.95 | 40.6 | 0.15 | 0.47 | √ |
| N/Ca | 0.34 | 33.2 | 0.01 | 0.40 | 47.4 | 0.04 | 0.25 | |
| Ca/N | 3.37 | 36.9 | 1.55 | 3.10 | 43.6 | 1.82 | 0.85 | √ |
| N/Mg | 0.20 | 29.6 | 0.004 | 0.21 | 33.7 | 0.01 | 0.40 | |
| Mg/N | 5.33 | 28.1 | 2.24 | 5.16 | 28.2 | 2.12 | 1.06 | √ |
| P/K | 4.80 | 14.6 | 0.49 | 6.33 | 33.5 | 4.51 | 0.11 | |
| K/P | 0.21 | 12.4 | 0.001 | 0.18 | 32.0 | 0.003 | 0.33 | √ |
| P/Ca | 1.86 | 29.9 | 0.31 | 2.03 | 41.0 | 0.69 | 0.45 | |
| Ca/P | 0.60 | 33.7 | 0.04 | 0.58 | 38.9 | 0.05 | 0.80 | √ |
| P/Mg | 1.10 | 24.6 | 0.07 | 1.11 | 34.3 | 0.14 | 0.50 | √ |
| Mg/P | 0.97 | 25.5 | 0.06 | 0.99 | 31.1 | 4.10 | 0.01 | |
| K/Ca | 0.39 | 31.4 | 0.02 | 0.34 | 39.0 | 0.02 | 1.00 | √ |
| Ca/K | 2.78 | 33.0 | 0.84 | 3.44 | 40.2 | 1.92 | 0.44 | |
| K/Mg | 0.23 | 26.8 | 0.004 | 0.20 | 76.8 | 0.02 | 0.20 | √ |
| Mg/K | 4.60 | 24.5 | 1.27 | 6.34 | 48.8 | 9.60 | 0.13 | |
| Ca/Mg | 0.63 | 27.9 | 0.03 | 0.62 | 40.9 | 0.06 | 0.50 | √ |
| Mg/Ca | 1.75 | 36.2 | 0.40 | 1.96 | 48.6 | 0.91 | 0.44 | |

**Table (2): Nutrients indices as related to yield production of corn plants**

| Treatment | Grain yield ton/fed | Nutrient Indices | | | | |
|---|---|---|---|---|---|---|
| | | N | P | K | Ca | Mg |
| $N_{100}P_{40}K_{40}$ | 2.5 | - 14.7 | - 1.25 | 4.12 | 4.47 | 7.39 |
| $N_{100}P_{40}K_{60}$ | 2.51 | - 23.3 | - 11.6 | 7.24 | 9.67 | 17.9 |
| $N_{100}P_{60}K_{40}$ | 2.55 | - 2.46 | 2.49 | - 1.30 | - 1.43 | 2.69 |
| $N_{150}P_{40}K_{40}$ | 2.64 | - 16.1 | 15.4 | 0.99 | - 0.03 | - 0.26 |
| $N_{150}P_{40}K_{60}$ | 2.70 | - 5.05 | 0.85 | 6.39 | - 0.68 | - 1.51 |
| $N_{150}P_{60}K_{40}$ | 2.80 | -5.47 | - 2.24 | 5.35 | 1.73 | 0.63 |
| $N_{200}P_{40}K_{40}$ | 3.03 | - 3.60 | - 7.96 | 10.6 | 17.8 | - 16.8 |
| $N_{200}P_{40}K_{60}$ | 2.96 | - 0.17 | - 2.12 | 12.3 | 4.55 | - 14.6 |
| $N_{200}P_{60}K_{40}$ | 3.03 | - 13.1 | 12.0 | 3.96 | 3.96 | - 6.85 |
| $N_{200}P_{60}K_{60}$ | 3.11 | - 0.08 | 3.35 | 14.4 | - 5.38 | - 12.2 |
| $N_{200}P_{80}K_{40}$ | 3.06 | 1.11 | - 0.53 | - 12.0 | 6.92 | 4.47 |
| $N_{200}P_{80}K_{60}$ | 3.16 | - 5.02 | - 5.16 | 13.3 | 9.28 | - 12.4 |

Earlier studies confirmed the universal applicability of DRIS norms of several crops, regardless of variety and age of crop at sampling, when the norms were established from broad data bases (**Sumner 1981 and Elwali and Gascho, 1984**). However, **Escano *et al* (1981)** using a small data base of observations in each of the low-and high- yield subpopulations, they concluded that local calibration is necessary to improve the accuracy of DRIS diagnosis.

Those norms were used in the estimation of DRIS indices for N, P, K, Ca and Mg are shown in (Table, 2). It is obvious that when $N_{100}$ $P_{40}$ $K_{40}$ was handled, the N had the most negative index and N fertilization level must be increased to have a valuable increase in yield production. Increasing P or K fertilization level didn't cause such yield increase obtained by increasing N fertilization level. The $N_{200}P_{80}K_{60}$ and $N_{200}P_{60}K_{40}$ were the best treatment in order to achieve the maximum corn crop, this results are consistent with **Abd El-Rheem and Youssef (2012)**.

**Corresponding author**
**Youssef, R. A**
Soils and Water Use Dept., National Research Centre, Dokki, Giza, Egypt.
Refatay@gmail.com

**References**

1. **Abd El-Rheem, Kh. M. and R. A. Youssef (2012).** Norms establishment of the Diagnosis and Recommendation Integrated System (DRIS) for nutritional diagnosis of peanut.10th International Egyptian Soil Science Society (ESSS), 4th International Conference of " on-Farm Irrigation and Agroclimatology 5-8 November 2012, America, Alexandria, Egypt.
2. **Bailey, J. S.; J. A. M. Beattie and D. J. Kilpatrick (1997).** The Diagnosis and Recommendation Integrated System (DRIS) for diagnosing the nutrient status of grassland swards: I. Model establishment. Plant and Soil, 197, 127-135.
3. **Baldock, J. O. and E. E. Schulte (1996).** Plant analysis with standardized scores combines DRIS and sufficiency range approaches for corn. Agronomy Journal, Madison, 88, 448-456.
4. **Beaufils, E. R. (1973).** Diagnosis and Recommendation Integrated System (DRIS). University of Natal, Pietermaritzburg, S. Africa., (Soil Science Bulletin, 1).
5. **Chapman, H.D. and R. E. Pratt (1961).** Methods of analysis for soil, Plants and Water. Dept. of Soil, Plant Nutrition, Univ. of California. U.S.A.
6. **Cotteine, A. (1980).** Soil Management for Conservation and Production. New York, pp. 245-250.
7. **Elwali, A.M.O. and G. J. Gascho (1984).** Soil testing, foliar analysis and DRIS as guides for sugarcane fertilization. Agron. J., 76, 466-470.
8. **Escano, C.R., C. A. Jones and G. Uehara (1981)**. Nutrient diagnosis in corn grown on Hydric Dystrandepts: II.Comparison of two systems of tissue diagnosis. Soil Sci. Soc. Am. J. 45:1140-1144.
9. **Hallmark, W. B., V. J. de Mooy and J. Pesek (1987).** Comparison of two DRIS methods for diagnosing nutrient deficiencies. J. Fert., 4, 151:158.

10. **Hartz, T. K.; E. M. Miyao and J. G. Valencia (1998).** Evaluation of the nutritional status of processing tomato. HortScience, Alexandria, 33, 830-832.
11. **Hundal, H. S.; S. Dhanwinder and J. S. Brar (2005).** Diagnosis and recommendation integrated system for monitoring nutrient status of mango trees in sub mountainous area of Punjab, India. Philadelphia, PA, ETATS-UNIS: Taylor and Francis.
12. **Payne, G. G.; J.E. Rechcigl and R. L. Stephenso (1990)**. Development of diagnosis and recommendation integrated system norms for bahigrass. Agronomy Journal, Madison, 82, 930-934.
13. **Rathfon, R. A. and E. J. A. Burger (1991).** Diagnosis and Recommendation Integrated System (DRIS) nutrient norms for Fraser fir Christmas trees. Forest Science, 37, 998:1010.
14. **Sumner, M. E. (1977).** Preliminary N, P and K foliar diagnostic norms for soybeans. Agron. J. 69:226-230.
15. **Sumner, M. E. (1981).** Diagnosis of sulfur requirements of corn and wheat using foliar analysis. Soil Sci. Soc. Am. J. 45:87-90.
16. **Walworth, J. L. and M. E. Sumner (1986).** Foliar diagnosis – a review. In: Tinker BP (ed) Advances in plant nutrition. 3: 193-241.
17. **Walworth, J. L. and M. E. Sumner (1987).** The Diagnosis and Recommendation Integrated System (DRIS). Advances in Soil Sciences, 6, 149-188.
18. **Walworth, J. L.; M. E. Sumner, R.A. Isaac and C. O. Plank (1986).** Preliminary DRIS norms for alfalfa in the Southeastern United States and a comparison with the Midwest norms. Agronomy Journal, Madison, 78, 1046-1052.


7/2/2013