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# Nutrients Status and Establishment of Sufficiency Ranges for Different Nutrients of Rice Grown in Saline Soil through Diagnosis and Recommendation of the Integrated System

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**Abstract :** Under saline condition there are still no studies on the use of Diagnosis and Recommendation of the Integrated System(DRIS) for nutritional diagnosis of the rice plants. DRIS norms for rice were developed during summer season of 2014 in SahlEl-Hosseinieh, El-Sharkia governorate, Egypt. Those soils characterized by high salinity, and decrease in the amount of crop output as a result of this high salinity. To carry out this research, sixty samples of leaf were analyzed for N, P, K, Fe, Zn and Mn contents and respective yields were recorded of rice fields from Sahl El-Hosseinieh, El-Sharkia governorate. The data were divided into high- yielding (≥ 3.6 ton $ha^{-1}$) and low- yielding (<3.6 ton $ha^{-1}$) sub-population and the norms were computed using standard DRIS method. The forms of expression for different nutrients and their norms were selected, based on the highest variance ratio between low and high yielding population. DRIS norms for N, K and Fe 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 N, K and Fe status of rice in order to get high value of the rice yield under saline soil condition. The DRIS derived sufficient ranges for N, P and K from nutrient survey of rice crop were 2.9to 3.23, 0.175 to 0.503 and 1.776 to 1.988 %, respectively. The sufficient ranges for Fe, Zn and Mn were 149.1 to 162.3, 44.36 to 60.52 and 65.40 to 90.22 ppm, respectively. As well as the sufficiency ranges of nutrients derived DRIS method of saline soil were 66.07 – 73.92, 7.149 – 7.437, 226.8 – 244.3,13.40 – 13.66, 0.443 – 0.579 and 8.233 – 8.383 ppm of N, P, K, Fe, Zn and Mn, respectively.
**Key words :** DRIS norms, Rice, Yield, Nutrients content. Sufficiency ranges.

## Introduction:

Saline soil is characterized by an increase of the proportion of salts, especially sodium salts; these salts greatly affect the growth of plants and working to reduce the productivity of crops. Soil salinity is more common in arid and semi-arid regions than in humid regions[1,2]. Saline soil need some appropriate service in order to be suitable for the cultivation of various crops, such as good washing of the soil and selection of salt-tolerant crops, as well as choosing the right fertilizer for this type of soils[3].

The increase in salinity of aquatic ecosystems leads to the plants affected by several things, including ionic and osmotic stresses[4], several biochemical and morphological alterations as well as nutrient imbalance[5].

Nutrients, in general, have several functions in plant structure, metabolism and osmoregulation of plant cells[6]. However, one of the most important salt stress effects on plants is induced by nutritional disorders, which result from salinity effect on availability, absorption and transport of nutrients within the plant[7].

Nutrient deficiency as well as iontoxicity and osmotic stress are factors attributed tothe deleterious effect of salinity on plant growth and productivity [8].

The Diagnosis and Recommendation Integrated System (DRIS) was developed by Beaufils[9]. These approach was used the nutrient ratio a stable criteria with respect to the age of plants and position of leaves, has been proved useful in the interpretation of leaf tissue analysis. DRIS is based on the balance between the different nutrients and indicated to the nutrient most likely to be limiting, as well as the order, in which other nutrients are likely to become limiting and was able to diagnose plant nutrient needs early in the life of crops than sufficiency range approach[10]. DRIS norms have addressed this issue employing a variety of diagnostic methods, leading to many discrepancies in the interpretation of results. Hence, the nutrient constraint diagnosis seldom addressed the original problems that existed in the field, and therefore, failed frequently to induce the desired response of fertilization [11,12].

The objective of this work was establishment appropriate norms for the rice crop in Sahl El-Hosseinieh, El-Sharkia governorate, Egypt, seeking to use the DRIS method for its nutritional diagnosis. The sufficiency and deficiency ranges were derived with the DRIS method, and these were used to monitor the nutrient status of rice plants grown in saline soil.

## Materials and Methods

A total of 35rice fields were sampled during the 2014 season from Sahl El-Hosseinieh, El-Sharkia governorate, Egypt. To identify the initial characteristics of the experimental soil, a surface soil sample (0-30 cm depth) was collected before the beginning of the experiment and subjected to some physical and chemical analyses according to Jackson[13], Page *et al.*[14]and Gee and Bauder[15]as well as some soil essential nutrients status [16,17,18]. The obtained results are presented in Table, 1.

**Table (1): Some physical and chemical properties of the soil used.**

| Soil property | Value | Soil property | Value |
|---|---|---|---|
| Particle size distribution % | | pH (1:2.5 soil suspension) | 8.50 |
| Coarse sand | 3.00 | ECe (dS $m^{-1}$) | 20.5 |
| Fine sand | 8.40 | Soluble ions (meq $L^{-1}$) | |
| Silt | 36.5 | $Ca^{++}$ | 18.2 |
| Clay | 52.1 | $Mg^{++}$ | 21.7 |
| Texture | Clay | $Na^{+}$ | 267.1 |
| **Available Nutrients (mg $kg^{-1}$)** | | $K^{+}$ | 0.50 |
| | | $CO_3^{--}$ | nd* |
| N | 200.0 | $HCO_3^{-}$ | 10.50 |
| P | 8.00 | $Cl^{-}$ | 246.0 |
| K | 140.0 | $SO_4^{--}$ | 51.0 |
| Fe | 9.00 | | |
| Zn | 1.90 | | |
| Mn | 1.81 | | |

nd : not detected

Rice yield data and sixty leaf samples were collected in commercial rice fields. Rice yield data were collected from sampled fields. Yield and foliar nutrient concentrations built a databank, which was divided into high- (≥ 3.6 ton $ha^{-1}$) and low- yield (<3.6 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[19]. 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 [20], K was determined by Flame Photometer, while Fe, Zn and Mn were determined using atomic absorption spectrophotometer.

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[21].

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[22]. 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'[21]. 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.

The sufficiency range for leaf tissues of ricecrop was determined by the DRIS technique. The range of ‘sufficiency’s are the values derived from the mean ± 4/3 SD and mean ± 8/3 SD (standard deviation),respectively [23,24,25]. The value of nutrients< (mean-8/3 SD) are considered deficient, whereas their low range included all values between> (mean-8/3 SD) and < (mean - 4/3 SD). Values between> (mean - 4/3 SD) and < (mean + 4/3 SD) are taken as sufficient, whereas the range between >(mean + 4/3 SD and <(mean + 8/3 SD) are expressed as high. The nutrient concentrations > mean + 8/3 SD are expressed as excessive or toxic.

## Results and Discussion

DRIS norms established for rice crop grown in saline soil should be useful to evaluate rice nutritional state and to calibrate fertilizer programs[26], but they must be validated before rice growers adopt them. 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, 2). Nutrient ratio as DRIS norm (i.e.: N/K or K/N) have been selected based on $S^2_l/S^2_h$ ratio[27]. The higher $S^2_l/S^2_h$ ratio, the more specific the nutrient ratio must be in order to obtain a high yield [28].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 N, K and Fe 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 N, K and Fe status of rice. 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 rice production under saline condition.

**Table (2): 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 rice 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 | 9.200 | 12.14 | 1.248 | 7.831 | 6.449 | 0.255 | 0.204 | |
| P/N | 0.110 | 11.82 | $1.7*10^{-4}$ | 0.128 | 7.031 | $8.1*10^{-5}$ | 0.479 | √ |
| N/K | 1.629 | 2.640 | 0.002 | 1.628 | 3.440 | 0.0031 | 1.696 | |
| K/N | 0.614 | 2.606 | $2.6*10^{-4}$ | 0.615 | 3.577 | 0.0005 | 1.891 | √ |
| N/Fe | 196.9 | 2.249 | 19.616 | 198.1 | 1.747 | 11.98 | 0.611 | √ |
| Fe/N | 0.005 | 20.00 | $1*10^{-6}$ | 0.005 | 2.000 | $1*10^{-8}$ | 0.010 | |
| N/Zn | 592.4 | 8.174 | 2344.5 | 531.6 | 6.127 | 1060.8 | 0.452 | |
| Zn/N | 0.002 | 7.500 | $2.3*10^{-8}$ | 0.0019 | 6.316 | $1.44*10^{-8}$ | 0.640 | √ |
| N/Mn | 396.2 | 7.691 | 928.4 | 359.1 | 5.010 | 323.6 | 0.349 | |
| Mn/N | 0.003 | 6.333 | $3.6*10^{-8}$ | 0.003 | 5.333 | $2.56*10^{-8}$ | 0.709 | √ |
| P/K | 0.179 | 11.73 | $4.4*10^{-4}$ | 0.208 | 3.750 | $6.08*10^{-5}$ | 0.138 | √ |
| K/P | 5.652 | 12.51 | 0.500 | 4.806 | 3.808 | 0.033 | 0.067 | |
| P/Fe | 21.71 | 12.36 | 7.198 | 25.37 | 5.191 | 1.734 | 0.241 | √ |
| Fe/P | 0.047 | 12.98 | $4*10^{-5}$ | 0.04 | 5.500 | $4.84*10^{-6}$ | 0.130 | |
| P/Zn | 64.9 | 9.29 | 36.349 | 68.04 | 6.695 | 20.75 | 0.571 | √ |
| Zn/P | 0.016 | 9.375 | $2.3*10^{-6}$ | 0.015 | 6.667 | $1*10^{-6}$ | 0.444 | |
| P/Mn | 43.35 | 7.204 | 9.753 | 45.9 | 2.166 | 0.988 | 0.101 | √ |
| Mn/P | 0.023 | 8.696 | $4*10^{-6}$ | 0.022 | 2.273 | $2.5*10^{-7}$ | 0.062 | |
| K/Fe | 120.9 | 1.346 | 2.647 | 121.8 | 2.022 | 6.066 | 2.292 | |
| Fe/K | 0.008 | 1.375 | $1.2*10^{-8}$ | 0.008 | 2.500 | $4*10^{-8}$ | 3.306 | √ |
| K/Zn | 363.8 | 8.278 | 907.0 | 326.5 | 5.470 | 319.0 | 0.352 | |
| Zn/K | 0.003 | 6.667 | $4*10^{-8}$ | 0.0031 | 6.452 | $4*10^{-8}$ | 1.000 | √ |
| K/Mn | 243.5 | 8.357 | 414.1 | 220.5 | 3.130 | 47.64 | 0.115 | |
| Mn/K | 0.004 | 7.5 | $9*10^{-8}$ | 0.005 | 4.000 | $4*10^{-8}$ | 0.444 | √ |
| Fe/Zn | 3.011 | 8.834 | 0.071 | 2.683 | 5.516 | 0.0219 | 0.310 | |
| Zn/Fe | 0.335 | 8.955 | 0.001 | 0.374 | 5.294 | 0.0004 | 0.436 | √ |
| Fe/Mn | 2.016 | 9.077 | 0.033 | 1.812 | 3.775 | 0.0047 | 0.140 | |
| Mn/Fe | 0.5 | 9.2 | 0.002 | 0.553 | 3.797 | 0.0004 | 0.208 | √ |
| Zn/Mn | 0.67 | 6.119 | 0.002 | 0.677 | 6.056 | 0.0017 | 1.000 | √ |
| Mn/Zn | 1.498 | 6.409 | 0.010 | 1.483 | 6.339 | 0.009 | 0.959 | |

The DRIS approach can also be employed to compute deficient, low, sufficient, high and exceed ranges for nutrients, following the procedure developed by Beaufils[23], Beaufils and Sumner[24]and Bhargava[25]. The Sufficiency ranges of N, P, K, Fe, Zn and Mn derived from a nutrient indexing survey of rice crop grown in saline soil are shown in (Table, 3).

**Table (3): Optimum ranges of nutrients derivedDRIS method of rice plants grown in saline soil.**

| Nutrients | Deficient | Low | Sufficient | High | Exceed |
|---|---|---|---|---|---|
| N (%) | < 2.737 | 2.737 – 2.900 | 2.900 – 3.230 | 3.230 – 3.390 | > 3.390 |
| P (%) | < 0.011 | 0.011 – 0.175 | 0.175 – 0.503 | 0.503 – 0.667 | > 0.667 |
| K (%) | < 1.598 | 1.598 – 1.776 | 1.776 – 1.988 | 1.988 – 2.166 | > 2.166 |
| Fe (ppm) | < 138.2 | 138.2 – 149.1 | 149.1 – 162.3 | 162.3 – 173.2 | > 173.2 |
| Zn (ppm) | < 30.86 | 30.86 – 44.36 | 44.36 – 60.52 | 60.52 – 74.02 | > 74.02 |
| Mn (ppm) | < 44.68 | 44.68 – 65.40 | 65.40 – 90.22 | 90.22 – 110.9 | > 110.9 |

It was found that the sufficient ranges for N, P and K were 2.9 to 3.23, 0.175 to 0.503 and 1.776 to 1.988 %, respectively. As well as the sufficient ranges for Fe, Zn and Mn were 149.1 to 162.3, 44.36 to 60.52 and 65.40 to 90.22 ppm, respectively. Whereas the deficient values of N, P, K, Fe, Zn and Mn when the concentration of these nutrients are less than 2.737 %, 0.011%, 1.598%, 138.2 ppm, 30.86 ppm and 44.68 ppm , respectively, under saline condition. Ravi *et al.*[29]showed that the DRIS derived optimum ranges for N, P, K from nutrients survey of rice crop were 2.2 ton3.6, 0.30 to 0.38 and 2.02 to 2.89 %, respectively; as well as the optimum ranges of Fe and Zn were 91.7 to 167.8 and 14.9 to 26.3 mg $kg^{-1}$, respectively. Whereas the low values for N, P, K, Fe and Zn for rice crop were established as 0.2, 0.3, 2.02 % and 91.69 and 14.93 mg $kg^{-1}$ , respectively.

The Sufficiency ranges of N, P, K, Fe, Zn and Mn derived from a nutrient indexing survey of saline soil are shown in (Table, 4). The sufficient ranges for N, P, K, Fe, Zn and Mn of saline soil were 66.07 – 73.92, 7.149 – 7.437, 226.8 – 244.3, 13.40 – 13.66, 0.443 – 0.579 and 8.233 – 8.383 ppm, respectively. The deficient ranges of N, P, K, Fe, Zn and Mn when the concentration of these nutrients less than 62.15, 7.005, 218.0, 13.27, 0.375 and 8.159, respectively.

**Table (4): Optimum ranges of nutrients derived DRIS method of saline soil.**

| Nutrients (ppm) | Deficient | Low | Sufficient | High | Toxic |
|---|---|---|---|---|---|
| N | <62.15 | 62.15 – 66.07 | 66.07 – 73.92 | 73.92 – 77.85 | >77.85 |
| P | <7.005 | 7.005 – 7.149 | 7.149 – 7.437 | 7.437 – 7.581 | >7.581 |
| K | <218.0 | 218.0 – 226.8 | 226.8 – 244.3 | 244.3 – 253.1 | >253.1 |
| Fe | <13.27 | 13.27 – 13.40 | 13.40 – 13.66 | 13.66 – 13.79 | >13.79 |
| Zn | <0.375 | 0.375 – 0.443 | 0.443 – 0.579 | 0.579 – 0.647 | >0.647 |
| Mn | <8.159 | 8.159 – 8.233 | 8.233 – 8.383 | 8.383 – 8.457 | >8.457 |

Use of DRIS with soil data provides as advantage of taking into account, the nutrients balance and ranking nutrients in terms of abundance relative to optimum levels. Optimizing soil fertility has recently emerged as a new field of investigation, which ensures maximum yield under a wide range of soil conditions [30,31,32,33].

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