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DRIS norms for identification of yield limiting nutrients in groundnut of Vijayapura district of Karnataka

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Abstract
A survey was conducted during 2020-21 in groundnut fields of Indi and Sindagi talukas of Vijayapura district. Leaf samples (n=97) of groundnut (fully matured 1stpair of leaves at full bloom stage of groundnut) were collected and analysed for macro-and micro-nutrient status. The entire population was divided into two *i.e.* low- and high-yielding population based on cut-off yield of 6 q/acre. A data bank was established to develop nutrient diagnostic norms and identification of most yield limiting nutrients using Diagnosis and Recommendation Integrated System (DRIS) approach. The DRIS is a dual ratio concept where the nutrient concentration ratios were considered rather than absolute nutrient concentrations in isolation. The results revealed that the mean of groundnut leaf nutrient concentrations of N, P, K and S were 3.20, 0.43, 2.11 and 0.07 percent respectively. Whereas, micronutrients mean of Fe, Mn and Zn were 119.42, 67.65 and 18.72 µg/g respectively in high yielding groundnut fields. Whereas, low yielding groundnut fields, the mean of groundnut leaf nutrient concentrations of N, P, K, S, and Fe, Mn and Zn were 2.86, 0.32, 2.16, 0.06 percent and 119.20, 66.50 and 18.726 µg/g respectively. A total of twenty-one nutrient ratio expressions used as diagnostic norms from high yielding population are provided. The important nutrient ratio expressions were: N/K (1.52), Zn/N (5.86), Fe/K (56.6), Zn/K (8.87), Fe/Zn (6.39) and Mn/Zn (3.62) *etc*. were from a physiological point of perspective equally significant *etc*. The diagnosis of nutrient imbalance through DRIS indices indicated that P is most yield limiting nutrient followed by S and Fe in the low yielding groundnut fields.

Keywords: Groundnut, DRIS, foliar diagnosis, leaf composition and yield limiting nutrient

Introduction
Groundnut (*Arachis hypogaea* L) is also known as peanut is a legume crop grown mainly for its edible seeds and oil purpose. The main yield limiting factors in semiarid regions are drought and high temperature stress. Apart from nitrogen, phosphorus, potassium, sulphur and other nutrient deficiencies causing significant yield losses are calcium, iron and boron. Groundnut is highly responsive to fertilizers and exhibits sensitiveness to the availability of nutrients. One of the major factors limiting pod production in groundnut is lack of a suitable nutrition program. The groundnut yields may be low because of excessive vegetative growth in winter following late or heavy N fertilization. The majority of Vijayapura district soils comes under medium black soil and suffering from salinity problem. Thus, the deficiencies of P and S, and to a lesser extent of B, Zn and Cu, may limit yield by restricting the set and subsequent development of groundnut pods (Singh and Chaudhari, 1997) [25].
The priority areas for nutrition research should include: the relationship between vegetative flushing and leaf nutrient content; the timing of fertilizer application during flowering, pegging and pod development. Nutrition management in groundnut is based on monitoring the leaf and soil nutrient levels and adjusting fertilizer practices is important to achieve higher yields in groundnut. In order to avoid any yield loss, the nutrient requirement of groundnut has to be carefully monitored through soil or leaf analysis. In this direction, leaf analysis is considered a more direct method of evaluating plant nutritional status than soil analysis (Hallmark and Beverly, 1991) [11].

Mineral nutrition of groundnut is better understood by tissue analysis. The basic principle involved in leaf analysis is that the concentration of a nutrient within the plant at any particular stage is an integrated value of all the factors that have influenced the nutrient concentration up to the time of sampling. The use of chemical analysis of plant material for diagnostic purposes is based on the assumption that causal relationships exist between growth rate (yield) and nutrient content in the shoot dry matter (Gustave *et al.*, 2012) [10].

Several approaches have been adopted for nutritional diagnosis of crops based on leaf analysis which include the Critical value approach (CVA), the Sufficiency range approach (SRA), Diagnosis and Recommendation Integration System (DRIS) (Beaufils, 1973; Walworth and Sumner, 1987) [4]. Among these approaches, DRIS is the recent concept that could be implemented to diagnose nutritional imbalances from tissue analyses.

The DRIS uses nutrient ratios and the nutritional balancing concept for interpretation of tissue analysis (Beaufils, 1973 and Walworth and Sumner, 1987). According to Baldock and Schulte (1996) [3], there are four advantages of DRIS; (1) presents continuous scale and easy interpretation; (2) allows nutrient classification (from the most deficient up to the most excessive); (3) can detect cases of yield limiting due to nutrient imbalance, even when none of the nutrients is below the critical level, (4) allows to diagnose the total plant nutritional balance, through an nutrient imbalance index.

The DRIS had already been used to assess the nutritional status of plants in several such crops such as; corn, soybean and wheat (Sumner, 1977a and b) [29, 30], sugarcane (Elwali and Gascho, 1984 [9]; Jones and Bowen 1981 [17] and Hundal *et al.*, 2005) [14], potato (Johnson and Sumner, 1980 [16]; and Mackay *et al.*, 1987) [18], sunflower (Hundal *et al.*, 2002) [13], rice (Singh and Agarwal, 2007) [26] and cotton (Dhanwinder *et al.* 2012) [8] in annual crops and Litchi (Savita *et al.*, 2017) [23]. Thus, the present investigation was undertaken based on hypothesis of identification of nutrient imbalances which would help the groundnut growers (farmers) to prioritize investments in nutrient inputs. The aims of this study are based on following objectives are

1. To develop leaf nutrient norms/guides using Diagnosis and Recommendation Integration System (DRIS) in groundnut.
2. To identify yield limiting nutrients and nutrient imbalances in low yielding areas/fields of groundnut through DRIS indices.

Material and Methods

1. Collection of leaf and soil samples from groundnut fields

A survey was conducted during 2020-21 in groundnut of Indi and Sindagi talukas of Vijayapura district. Leaf samples (n=97) of groundnut (fully matured 1st pair of leaves at full bloom stage of groundnut) were collected as out lined by Bhargava and Raghupathi (2005) [6] Leaf samples (n=97) of and soil samples (n=97) of groundnut were collected. It is essential to select a specific part of the same physiological age at a definite location on the plant at definite stage of growth for comparison. From each field (1 acre) 50 to 60 groundnut plants were selected and from which 100 leaves were collected randomly to form a composite and representative sample. The samples were taken to the laboratory on the same day for further processing and analysis. The soil samples were also collected following standard produce from each groundnut field.

2. Processing of leaf and soil samples

After collection of leaf samples (n=97) and soil samples (n=97) of groundnut fields were brought to laboratory and processed following standards procedure and analysed for macro-and micro-nutrient status to develop nutrient diagnostic norms and identification of most yield limiting nutrients in low yielding groundnut fields.

The leaf samples of groundnut were decontaminated by washing in sequence with tap water to remove the dirt or soil, then in 0.2% detergent solution and in N/10 HCl solution to remove residues of chemical spray materials on the leaf followed by washing in single and double distilled water. Excess water will be removed by pressing between the folds of blotting paper and leaf samples were dried in an oven at 75^0 C for 72 hours. After complete drying, the samples were powdered in Mixer grinder and stored in polycarbyl containers for analysis.

The leaf samples will be analysed for N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B. The samples were analysed (expect N) by taking one-gram materials digesting in di-acid mixture (9:4 ratio of nitric and perchloric acids) by using standard analytical methods (Jackson, 1973). Nitrogen was estimated by micro-kjeldhal method, whereas P, K and Swere analysed by vanado-molybdate, flame-photometer and turbidity methods respectively. Calcium and magnesium by titrimetric method and micronutrients *viz*. Fe, Mn, Cu and Zn will be analysed by using atomic absorption spectrophotometer (Tandon, 2005) [31].

The soil samples were dried in shade at ambient temperature, passed through 2 mm sieve and stored for further analysis. An aliquot of 2 mm sieved soil was ground using agate pestle and mortar to pass through 0.2 mm sieve for determination of organic carbon. The soil samples were analyzed for pH, EC, OC, available N, P, K, S, DTPA extractable Fe, Mn, Zn, and Cu (Tandon, 2005) [31].

3. Computations of DRIS norms and indices

For development of DRIS norms for groundnut, the whole population was divided into two populations namely high yielding and low yielding groups (Beaufils, 1973) [4] based on cutoff yield is 6 q/acre of groundnut. The DRIS approach uses nutrient ratios rather than the nutrient concentrations themselves. All possible combination of nutrient ratios involving two nutrients and their inverses were worked out. DRIS norms were calculated as described by Beaufils (1973) [4]; Walworth and Sumner (1987) [32].

The computer programme developed at Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bengaluru for DRIS was used for developing norms. After computing these ratios for each sample in the low and high yielding population, their means for the two groups were determined. The nutrient ratios whose variance ratios (variance of low yielding/variance of high yielding population) for the two subpopulations varied significantly were selected for developing DRIS norms.

The individual nutrients were also considered for the computation of DRIS norm in the same way as the nutrient ratios. The means of the nutrient ratios or individual nutrients from the high yielding population formed the diagnostics norms. The eight nutrients are N, P, K, S, Fe, Mn, Zn, and Cu. DRIS provides a means of ordering nutrient ratios into meaningful expressions in the form of indices. The DRIS indices were calculated as described by Walworth and Sumner (1987) [32] by using the following formula, as an example for one nutrient is given below.

For example, in case of N the indices are

N = 1/10[f (N/P)-f (K/N) +f (N/S)-f (Fe/N) +f (N/Mn)-f (Zn/N) +f (N/Cu)]
Where, when N/P is larger or equal to n/p,

$$f\,(N/P) = \frac{(N/P - 1)}{n/p} \times \frac{1000}{CV}$$

When N/P is smaller than n/p,

$$f\,(N/P) = \frac{(1 - n/p)}{N/P} \times \frac{CV}{1000}$$

In which N/P is the actual value of the ratio of N and P in the plant under diagnosis and n/p is the value of the norm (mean of the high yielding population) and CV is the co-efficient of variation for the population of n/p for the high yielding orchards. Similarly, the indices for other nutrients have been calculated using appropriate formulae. The absolute sum values of the nutrient indices generate an additional index called 'Nutritional Imbalance Index' (NII). This was worked out by taking the actual sum of the DRIS indices irrespective of sign. The greater was the sum, higher will be the imbalance of nutrients and vice versa.

4. Determination of leaf nutrient ranges

The norms for classification of nutrient status in plants were derived as outlined by Bhargava and Chadha (1993) [5] and Raghupathi and Bhargava (1999) [19]. Five leaf nutrient guide/ ranges have been derived using mean and standard deviation (SD) as deficient, low, optimum, high and excess for each nutrient. The 'optimum' nutrient range is the value derived from "mean – 4/3 SD to mean + 4/3 SD". The range 'low' was obtained by calculating "mean – 4/3 SD to mean – 8/3 SD" and the value below "mean – 8/3 SD" wasconsidered as 'deficient'. The value from "mean + 4/3 SD to mean + 8/3 SD" was taken as 'high' and the value above "mean + 8/3 SD" was taken as 'excessive'.

Results and Discussion

1. Soil nutrient status of groundnut fields

Range and mean of soil properties and soil nutrient status in different Groundnut fields of Vijayapura district.

2. Range and mean of soil properties and nutrient status

The range and mean values of soil properties and nutrient status of different (n= 97) are given in Table 1. The soil pH (1:2.5 soil water suspensions) ranged from 7.40 to 8.55 with a mean value 7.95. The electrical conductivity of these soils varied from 0.25 to 1.54 dSm^{-1} in 1:2.5 soil water suspensions. The soil organic carbon content ranged from 0.09 to 0.96 percent with a mean value of 0.42 percent. Alkaline $KMnO_4$ hydrolysable N, Olsen's P and Neutral 1N ammonium acetate (NH_4OAc) K ranged from 54.0 - 472.5, 5.40 - 68.9 and 44.0 - 701.0 kg ha^{-1} with the mean values of 192.22, 19.6 and 179.2 kg ha^{-1} respectively. The $CaCl_2$ (0.15%) extractable S content of soil varied from 6.00 - 76.50 mg kg^{-1} with a mean of 21.4 mg kg^{-1}. The DTPA extractable Fe in soils ranged from 1.02 - 4.50 mg $kg^{-1}$with a mean value of 2.26 mg kg^{-1} and soil Mn ranged from 0.96 -5.12 mg kg^{-1} with a mean value of 2.86 mg kg^{-1}. Whereas, the DTPA extractable Zn in soils ranged from 0.24- 0.69 mg kg^{-1} with a mean value of 0.48 mg kg^{-1}. Thus, the DTPA extractable Fe and Zn were at deficient/low level in these soils. Therefore, their requirement has to be supplied through external sources.

Table 1: Range and mean of soil properties and soil nutrient status in groundnut fields (n= 97)

Property	Range	Mean
pH (1:2 soil water suspension)	7.40 - 8.55	8.03
EC (dSm^{-1})	0.25 - 1.54	0.49
Organic carbon (%)	0.09 – 0.96	0.42
Alk. $KMnO_4$ hydroly. N (kg ha^{-1})	54.0 – 472.5	192.2
Olsen's P (kg ha^{-1})	5.40 - 68.9	19.6
Neutral 1N NH_4OAc K (kg ha^{-1})	44.0 - 701.0	179.2
0.15% $CaCl_2$extr. S (mg kg^{-1})	6.00 - 76.5	21.4
DTPA extr. Fe (mg kg^{-1})	1.02 - 4.50	2.26
DTPA extr.Mn (mg kg^{-1})	0.96 - 5.12	2.85
DTPA extr.Zn (mg kg^{-1})	0.24 - 0.69	0.48

3. Leaf nutrients status of high yielding groundnut fields (n=64)

The range and mean of leaf nutrients in high yielding groundnut fields presented in Table 2. The concentration of N ranged from 3.00 to 3.98 percent with an average value of 3.20 percent. The concentration of Leaf P varied from 0.12 to 0.68 percent with an average value of 0.43percent and the concentration of Leaf K ranged from 1.98 to 2.58percent with an average of 2.11percent. The concentration of the leaf S ranged from 0.01 to 0.16 percent with an average of 0.07percent. The level of leaf Fe varied from 25.00 to 136.00 µg/g with a mean of 119.42 µg/g and the concentration of leaf Mn ranged from 60.28 to 72.00 µg/g with a mean of 67.65 µg/g. Zinc concentration in leaves ranged from 17.08 to 20.84 µg/g with a mean value of 18.72 µg/g. Singh and Agarwal (2007) [26] in rice and Dhanwinder *et al.* (2012) [8] in cotton and Savita and Anjaneyulu (2008) [22] in sapota also reported wide variations in the concentration of micronutrients. The yield of groundnut ranges 6.00 to 8.00 q/acre with mean 6.88 q/acre.

Table 2: Range and mean of leaf nutrients concentration of high yielding fields of groundnut (n=64)

Nutrient	Unit	Range	Mean
N	%	3.00 - 3.98	3.20
P	%	0.12 - 0.68	0.43
K	%	1.98 - 2.58	2.11
S	%	0.01 - 0.16	0.07
Fe	mg/kg	25.00 - 136.00	119.42
Mn	mg/kg	60.28 - 72.00	67.65
Zn	mg/kg	17.08 - 20.84	18.72
Yield	q/acre	6.00 - 8.00	6.88

4. Range and mean of leaf nutrients concentration of low yielding fields of groundnut (n=33)

The range and mean of nutrients in low yielding fields of groundnut are presented in Table 3. Nitrogen concentration ranged from 2.20 to 3.13 percent with a mean value of 2.86 percent, while P and K concentrations ranged from 0.10 to 0.60 percent and 1.92 to 2.63 percent with mean values of 0.32 and 2.16 percent, respectively. S concentration in the leaves ranged from 0.01 to 0.12 percent with mean values of 0.06 percent, respectively. The range and mean values for Fe, Mn, and Zn concentrations in low yielding fields of groundnut were 109.0 to 132.0, 59.67 to 70.12, and 17.02 to 20.46 µg/g with the mean values of 119.2, 66.50 and 18.76 µg/g respectively. The yield of groundnut ranges 3.00 to 5.80 q/acre with mean 4.67 q/acre.

Table 3: Range and mean of leaf nutrients of low yielding groundnut fields (n=33)

Nutrient	Unit	Range	Mean
N	%	2.20- 3.13	2.86
P	%	0.10-0.60	0.32
K	%	1.92-2.63	2.16
S	%	0.01-0.12	0.06
Fe	mg/kg	109.0-132.0	119.2
Mn	mg/kg	59.67-70.12	66.50
Zn	mg/kg	17.02-20.46	18.76
Yield	q/acre	3.00-5.80	4.67

5. Macronutrient and micronutrients concentration in high yielding and low yielding of Groundnut fields

The leaf nutrient status stated the average nutrient concentration of N, P, Fe and Mn were marginally higher while that of K were marginally lower in high-yielding populations of groundnut as compared to low yielding population of groundnut. The presence of higher concentration of essential nutrients in high yielding population was also reported by Hundal *et al*. (2007) in guava [15], Raghupathi *et al*. (2004) [20] in mango and Anjaneyulu (2006) [2] in rose. There is not much changes occurred in S and Zn in between high and low yielding groundnut fields (Fig 1 and 2).

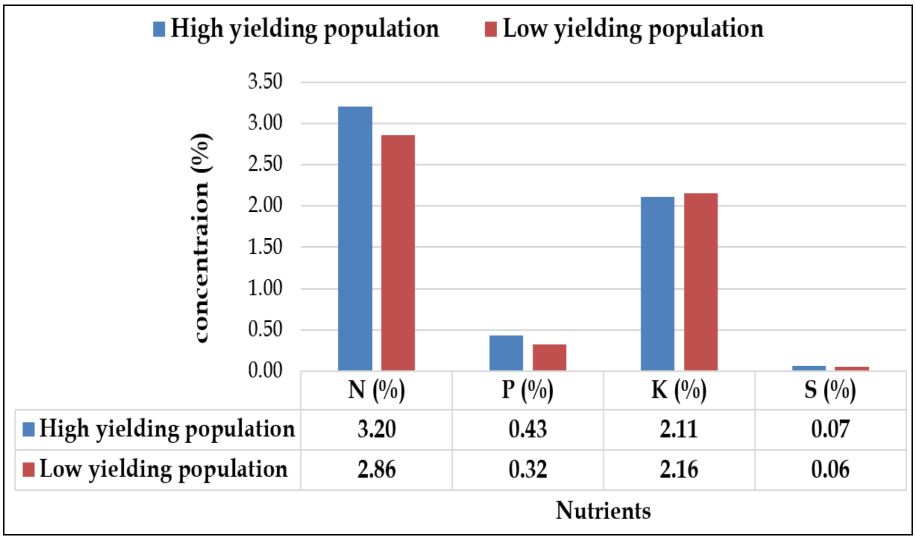

Fig 1: Macronutrient concentration in Groundnut leaf samples

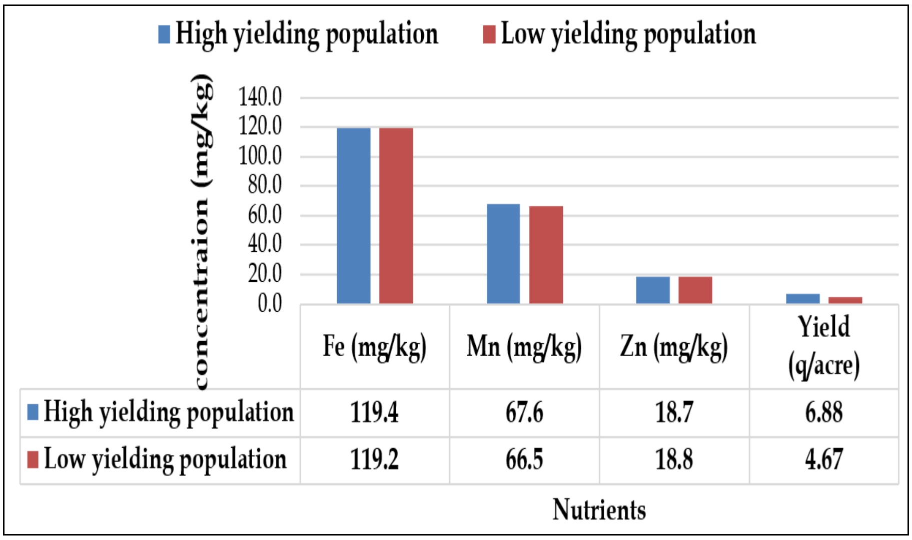

Fig 2: Macronutrient concentration in Groundnut leaf samples

6. DRIS ratio norms in groundnut

A total of twenty-one nutrient ratio expressions used as diagnostic norms from high yielding population are provided. Ideally, it was noted that for greater diagnostic accuracy, a specific nutrient ratio to be selected as a standard should have a high variance ratio and a low coefficient of variation between high and low yielding groups (Table 4). These nutrient ratio norms were worked out as derived by Bhargava (2002) [7] for grapes, Hundal and Arora (2001) [12] for Kinnow fruit, Raghupathi *et al.* (2004) [20] for mango. Thus, DRIS provides a reliable means of linking leaf nutrient concentrations to the yield of groundnut.

The important nutrient ratio expressions were: N/K (1.52), Fe/N (37.4), Mn/N (21.2), Zn/N (5.86), Zn/N (5.86), Fe/K (56.6), Mn/K (32.1), Zn/K (8.87), Fe/Mn (1.77), Fe/Zn (6.39) and Mn/Zn (3.62) *etc*. Showed lower co-efficient of variation when compared to others. Important expressions of nutrients with N were: P/N (0.14), N/K (1.52), S/N (0.02), Fe/N (37.4) and Mn/N (21.2). However, it is often difficult to consider all the fifty-five nutrient expressions for interpretation of leaf analysis data for diagnosis of nutrient imbalance (Hallmark and Beverly, 1991[12 and Sharma *et al.*, 2005) [24]. Therefore, among different expressions, the expression having higher physiological relevance needs to be considered.

The other important expressions of nutrients with K were: S/K (0.03), P/K (0.21), Fe/K (56.6), and Zn/K (8.87) for sulphur S/Fe (0.001), S/Mn (0.001), for iron Fe/Mn (1.77), Fe/Zn (6.39) were also from a physiological point of perspective equally significant. The coefficient of variation (CV) ranged from the smallest 8% for Zn/N and Zn/K, to the largest 80% for P/S, showing greater variation in their absolute concentrations in the high producing population.

Table 4: DRIS ratio norms in groundnut

Selected ratio	DRIS norms	CV (%)	Selected ratio	DRIS norms	CV (%)
P/N	0.14	37	S/K	0.03	42
N/K	1.52	8	Fe/K	56.6	12
S/N	0.02	44	Mn/K	32.1	8
Fe/N	37.4	12	Zn/K	8.87	7
Mn/N	21.2	6	S/Fe	0.001	73
Zn/N	5.86	7	S/Mn	0.001	46
P/K	0.21	37	S/Zn	0.004	42
P/S	8.14	80	Fe/Mn	1.77	12
Fe/P	347	64	Fe/Zn	6.39	12
P/Mn	0.01	38	Mn/Zn	3.62	8
P/Zn	0.02	36			

CV is co-efficient of variation expressed in percent

7. DRIS indices and nutrient imbalance index (NII) in groundnut

The DRIS norms established from high yielding groundnut fields were used to calculate DRIS indices from the foliar mineral composition of groundnut grown at various sites to identify the most needed nutrient elements as well as their order of requirement. The plant's nutrient imbalance is diagnosed by indices of DRIS. The DRIS offers a mathematical means of readily interpretable ordering a big number of nutrient ratios into nutrient indices. Table 5 presents the DRIS indices along with the nutrient imbalance index (NII), yield and nutrient requirement order of low yielding groundnut.

Depending on the magnitude of the indices, the order in which distinct nutrients restrict returns may also be stated. In GT-8 for instance, there NII were 172 in P (-76), K (-11), had negative signs, while others had positive signs. The GT-13, with the smallest NII of 30, had an index of N (-11), P (2), K (4), S (4), Fe (2), Mn (1) and Zn (1) the order yield limiting nutrients were N>Mn>Zn>P. The GT-34, showed the highest NII of 278 had an index of N (17), P (-94), K (41), S (-45), Fe (18), Mn (37) and Zn (26) the order yield limiting nutrients were P>S>N>Fe. In general, consider whole population among macronutrient P was the most yield limiting nutrient fallowed by S. N and K also showing as yield limiting nutrient only in few groundnut fields. Among micronutrient Fe also showing as yield limiting nutrient only in few groundnut fields. The GT-70 showed nutrient indices zero for sulfur indicated the optimum level, in the present investigation, the sum of indices ranged from 30 to 278 regardless of the sign.

Thus, DRIS simultaneously identified imbalances, deficiencies and excesses in crop nutrients and ranked them in the order of importance (Walworth and Sumner, 1987). DRIS norms established for groundnut crop should be useful to evaluate peanut nutritional
status and to calibrate fertilizer programs. The similar finding are also reported by Abd El-Rheem and Youssef, (2013) [1].

8. Leaf nutrient standards in groundnut

For plant nutrients, leaf nutrient standards or optimum ranges were developed based on mean concentrations of nutrients and standard deviation (SD) from high yielding population. The concentrations of nutrients categorized in groundnut as deficient, low, optimal, high and excessive based on the DRIS principle are showed in Table 6.

The optimum N ranged from 3.00-3.20 percent. The concentrations of leaf N were regarded to be less than 2.78 percent and more than 3.62 percent respectively deficient and excessive. The optimum P varied from 0.23 percent to 0.43 percent, which was generally much lower than other crops. The optimum K varied between 1.98 and 2.11 percent. The concentration of leaf K were regarded to be less than 1.82 percent and more than 2.41 percent respectively as deficient and excessive. The optimum concentration of S ranged from 0.04 to 0.07 percent. The optimum concentrations of Fe, Mn and Zn, ranged from 101.8 to 119.4, 63.3 to 67.7, and 17.5-18.7 mg/kg, respectively, among the micronutrients. The wide range observed might be mainly due to large variation in the available Fe and Mn contents in the surveyed fields (Raghupathi and Bhargava, 1999) [19].

Table 5: DRIS indices, NII, yields and order of nutrient requirement for selected low yielding groundnut fields.

Field no	N index	P index	K index	S index	Fe index	Mn index	Zn index	NII	yield per acre	Order of limiting nutrients
G T -8	7	-76	-11	19	9	34	17	172	5.0	P>K>N>Fe
G T – 12	1	15	13	-53	3	5	15	105	4.8	S>N>Fe>Mn
G T – 13	-15	2	4	4	2	1	1	30	3.5	N>Mn>Zn>P
G T - 15	2	-21	13	-23	12	3	15	90	4.8	S>P>N>Mn
G T – 20	5	-56	-15	9	21	14	22	142	3.5	P>K>N>S
G T – 32	11	-30	20	-69	14	28	27	199	5.5	S>P>N>Fe
G T – 33	-6	1	5	-49	25	18	6	110	5.0	S>N>P>K
G T – 34	17	-94	41	-45	18	37	26	278	4.5	P>S>N>Fe
G T – 35	-3	-2	12	-14	5	5	-3	43	5.0	S>N>Zn>P
G T – 39	-1	-12	4	-23	16	10	7	71	5.8	S>P>N>K
G T – 48	-5	9	6	-17	-1	8	0	46	5.0	S>N>Fe>Zn
G T -51	-6	2	-4	-24	-2	23	12	74	5.8	S>N>K>Fe
G T – 52	28	-14	22	-97	15	23	23	223	5.8	S>P>Fe>K
G T – 57	-3	3	6	-13	0	-4	11	40	5.5	S>Mn>N>Fe
G T – 63	1	-20	-3	-7	10	11	9	63	5.2	P>S>K>N
G T – 69	3	-41	-9	12	15	-3	24	106	3.5	P>K>Mn>N
G T – 70	-14	-4	8	0	8	-6	8	48	4.2	N>Mn>P>S
G T – 71	-39	4	8	-3	6	8	16	84	3.8	N>S>P>Fe
G T – 93	-3	-13	12	-11	-2	7	9	56	4.2	P>S>N>Fe

Table 6: Leaf nutrient standards in groundnut

Nutrient	Unit	Deficient	Low	Optimum	High	Excessive
N	%	<2.78	2.79-2.99	3.00-3.20	3.21-3.41	>3.62
P	%	<0.01	0.02-0.22	0.23-0.43	0.44-0.65	>0.86
K	%	<1.82	1.83-1.97	1.98-2.11	2.12-2.26	>2.41
S	%	<0.01	0.01-0.03	0.04-0.07	0.07-0.11	>0.15
Fe	mg/kg	<83.9	84.0-101.7	101.8-119.4	119.5-137.2	>154.9
Mn	mg/kg	<58.7	58.7-63.2	63.3-67.7	67.8-72.1	>76.6
Zn	mg/kg	<16.0	16.1-17.4	17.5-18.7	18.8-20.0	>21.4

9. Classification of low-yielding groundnut fields based on leaf nutrient norms

Low yielding fields have been categorized based on leaf nutrient standards in groundnut and the values are displayed in Table 7. The field classification stated that leaf N was optimal in 27 percent of fields and low in 48 percent of fields. On the other hand, 24 percent of the fields were optimal in P while the incidence of low P was not recorded in any of the fields. Leaf K was optimum in 48 percent fields and the incidence of high K was recorded only in 30 percent of the fields.

Sulfur was discovered to be the yield-limiting nutrient as leaf S was optimal only in 48 percent of fields and low in 9 percent of fields. In 52, 24 and 42 percent of the fields, were optimal Fe, Mn and Zn respectively.

Table 7: Classification of low-yielding groundnut fields (%) based on leaf nutrient standards

Nutrients	Deficient	Low	Optimum	High	Excessive
N	24	48	27	0	0
P	0	39	24	36	0
K	0	3	48	30	18
S	9	12	48	27	3
Fe	0	0	52	48	0
Mn	0	21	24	55	0
Zn	0	3	42	45	9

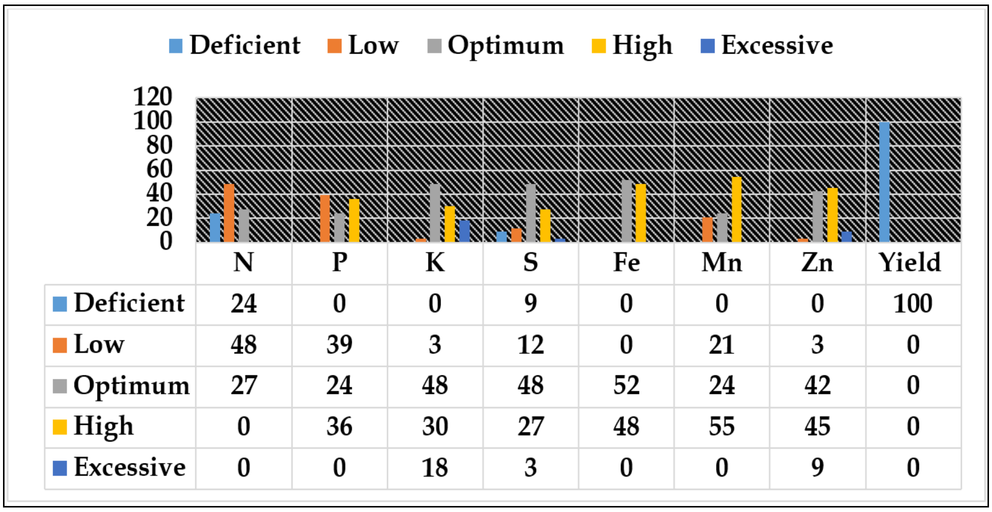

Fig 3: Classification of low-yielding groundnut fields (%) based on leaf nutrients norms

Conclusion

The diagnosis of nutrient imbalance through DRIS indices indicated that P is most yields limiting nutrient followed by S, whereas among the micronutrients most yield-limiting nutrients were, Fe in the low yielding groundnut fields. Recommendation of nutrients as soil application and foliar spray to the individual groundnut based on results obtained. To keep the record of nutritional status of soil and plants in groundnut of Vijayapura district for future benefit to the groundnut growers. DRIS is a holistic approach which identified nutrient imbalances and yield limiting nutrients in groundnut. It is proved an important technique for evolving nutrient management strategies for realizing higher yields in groundnut.

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