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Preliminary N, P and K Diagnostic Norms for Wheat (*Triticum aestivum*) Using DRIS

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ABSTRACT

The N, P and K foliar diagnostic preliminary norms for wheat (*Triticum aestivum*) were developed by using the Diagnostic and Recommendation Integrated System (DRIS) approach. These norms were developed from data sets on N, P and K composition in wheat plant samples and corresponding grain yields. The degree of nutrient imbalance in the plant was expressed in forms of a DRIS index, which measured the extent to which a particular nutrient deviated from the established norms. The DRIS assesses the nutrient balance in plant tissue and identifies not only the most limiting-element, but also the order in which other elements would become limiting. The diagnosis could be made for the deficiency of nutrients in the order of their requirements.

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INTRODUCTION

Critical values for diagnostic purpose determined through regression relationship between soil and plant analysis and crop yield, are specific to the conditions unique to the experiments involved and often do not hold under different agro-climatic conditions. The Diagnosis and Recommendation Integrated System- (DRIS) developed by Beaufils (1973), has been proved useful in the interpretations of plant analysis using nutrient concentration ratios (Summer, 1979). The approach has been found reliable in diagnosing nutrient requirement for short duration crops like soybean, sugarcane and potato (Summer, 1977a; Summer, 1979; Elwali and Gascho, 1984; Sharma, 1991). The DRIS identifies not only the most limiting element, but also the order in which other elements would become limiting and was able to diagnose plant nutrient needs early in the life of the crops than sufficiency range method (Beverly *et al.*, 1986). This paper reports the N, P and K foliar diagnostic preliminary norms developed from their composition in plant samples of wheat crop grown under different fertility condition.

MATERIALS AND METHODS

Preliminary foliar diagnostic norms for wheat were formulated by using data sets from the experiments conducted at College Agronomy Farm, G.A.U., Anand during 1991-93. Total 505 plant samples (3rd leaf) of different growth period (six to eight weeks after

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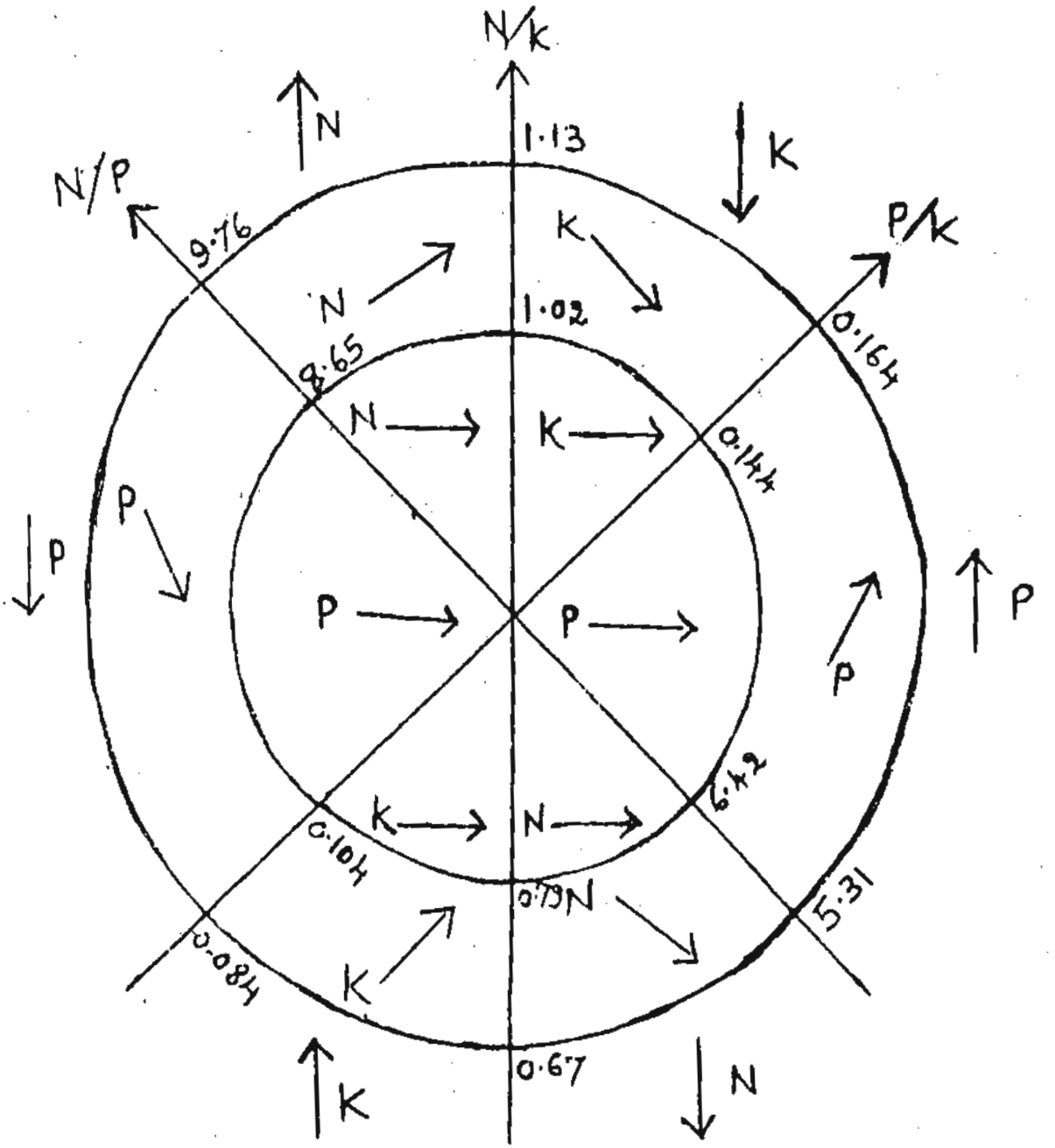
TABLE 1

Statistical parameters for different forms of wheat plant N, P and K expressions.

Paremeter	Forms of Expression								
	N	*P*	*K*	*N/P*	*N/K*	*K/P*	*K/N*	*P/N*	*P/K*
	-(% in dry matter)-								
					Low yielding population (A)+				
Mean	2.25	0.28	2.18	8.39	1.07	8.23	1.02	0.127	0.131
S.D.	0.50	0.08	0.43	2.20	0.33	2.32	0.34	0.031	0.035
C.V. %	22.36	28.44	19.81	26.20	30.35	28.15	32.80	24.18	26.46
Variance									
S_A	0.25	0.01	0.19	4.83	0.11	5.36	0.11	0.001	0.001
					High yielding population (B)+				
Mean	2.30	0.32	2.60	7.54	0.90	8.56	1.15	0.140	0.124
S.D.	0.26	0.07	0.35	1.67	0.17	2.23	0.22	0.034	0.031
C. V. %	11.53	21.27	13.40	22.17	19.12	26.02	18.86	23.98	24.76
Variance									
S_B	0.07	0.01	0.12	2.79	0.03	4.96	0.05	0.001	0.001
S_A/S_B	3.62*	1.40*	1.54*	1.73*	3.57*	1.08	2.40*	0.83	1.42*

+ Number of observations were 257 in A and 248 in B.



	$\bar{X}$	SD	CV%
N/P	7.54	1.67	22.17
N/K	0.90	0.17	19.12
P/K	0.12	0.03	24.76

Fig. 1. : DRIS chart for obtaining the qualitative order of requirement for N, P and K in wheat. Mean of significant expressions ((value at origin in chart) are : N/P = 7.54, N/K = 0.902, P/K = 0.124.

sowing) were collected and analysed for total N, P and K contents. The ground plant samples were analysed for N contents by wet digetion with H_2SO_4 following macro kjeldahl method and total P in the di-acid digested samples were estimated by phosphovanado-molybdate yellow colour method in HNO_3 system (Jackson, 1973); whereas total K was determined flame-photometrically.

Corresponding grain yield data were collected and the population was divided into two sub-population on the basis of yield : sub-population A, in which all yield exceeded more than 70 per cent of the maximum yield and sub-population B, with yields lower than this level. Each element in the plant sample was expressed as shown in Table 1. For each population, the mean, Standard Deviation (SD), Coefficient of Variation (CV%) and Variance (S) for each form of expression were computed. Expressions N/P, N/K and P/K were retained as being discriminatory since their variance ratio (SA/SB) was significant and their mean values for two sub-populations were nearly the same. These forms of expression were then interrelated in a three coordinate DRIS chart (Fig. 1). The point of origin in the centre of chart represents the mean of each expression N/P, N/K and P/K for the population of high yielding plants. The diameter of the inner and outer circles are 4 SD/3 and 8 SD/3 as has been dealt by Beaufils (1973) which takes care of the variability in the population.

The plant sample composition falling within the inner circle would be considered to be relatively balanced as is denoted by horizontal arrow (→). Away from the central zone along the axis, the degrees of imbalance between the two elements increases. This zone of imbalance is divided into two sub-zones, the first being slight to moderate imbalance which is denoted by an arrows at 45 degrees to the horizontal (↘) (↗), while the zone of marked imbalance beyond this circle, being either too high or too low is denoted by vertical arrows (↑), (↓) respectively. The DRIS indices were calculated for quantitative evaluations of the relative degree of imbalance of the nutrients using following equations :

$$\text{N Index} = + \left[\frac{f(N/P) + f(N/K)}{2} \right]$$

$$\text{P Index} = + \left[\frac{f(P/K) - f(N/P)}{2} \right]$$

$$\text{K Index} = - \left[\frac{f(N/K) + f(P/K)}{2} \right]$$

Where f (N/P) = 100 [(N/P/7.54)-1] 10/CV, when the value of N/P is > 7.54 and N/P = 100 [1-(7.54/N/P)] 10/CV when central value of N/P is < 7.54. In this case 7.54 is the mean. CV = coefficient of variation for high yielding sub-population. The other forms viz., N/K and P/K were derived in a similar way using the mean 0.902 for N/K and 0.124 for P/K. These indices have positive and negative values which always sum to zero as they measure the relative balance among N, P and K. The order of plant requirement is given by the most negative index being the most required and the most positive, the least. The diagnostic norms computed above were tested against independent data collected during 1992-93 from an ongoing long term fertilizer experiment at College Agronomy Farm, GAU, Anand. The

details of the treatments are shown in Table 2. This was done by selecting a particular treatment of interested element which is the nutrient most required by the plant and then satisfying the requirement by selecting another treatment in which that particular element is applied.

TABLE 2

Treatment details of long term fertilizer experiment at Anand.

Treatment	*Fertilizer application (kg/ha)*		
	N	*P*	*K*
T_1	0	0	0
T_2	FYM @ 25 t ha^{-1}	Every 3rd year	
T_3	60	0	0
T_4	60	30	0
T_5	60	30	60
T_6	120	0	0
T_7	120	60	0
T_8	120	60	120
T_9	135	65	0
T_{10}	135	65	135

RESULTS AND DISCUSSION

The results of the example for the ongoing experiment have been presented in Table 3. First treatment shows N as the most limiting when it was not applied to the wheat crop. The limitation of N goes on decreasing with increase in the rate of N application upto 120 kg ha^{-1} or when the N was applied as per soil test value i.e. 135 kg N ha^{-1} and its requirement was satisfied. Phosphorus becomes limiting followed by N and K when N rate is increased to 120 kg ha^{-1} or as per soil test value. The requirement of P gets satisfied at 60 kg P_2O_5 ha^{-1} or as per soil test value i.e. 65 kg P_2O_5 ha^{-1} when applied in combination with N application @ 120 kg ha^{-1} or 135 kg ha^{-1}. At this rate K becomes most limiting, but further increase in K applications (120-60-120 or 135-65-135 kg ha^{-1}) shows P as the most limiting one. Thus, the imbalance between elements goes on increasing at higher rates. So, while selecting the dose of nutrients, balance has to be struck somewhere when negative value of element (S) index is minimum. Since the sum total of index values is zero, the most desired balance would be when DRIS index is zero for all the elements. To obtain such an index value is rather rare, therefore, the balanced treatments are the one which give plant composition yielding DRIS indices having minimum negative values.

TABLE 3

Effect of fertilizer treatments on plant composition, DRIS indices and yield of wheat.

Treatment	Plant composition (%)			DRIS indices			Nutrient requirement	Grain yield (t/ha)
	N	P	K	N	P	K		
T_1	1.34	0.196	2.13	-16.11	-6.35	22.46	N>P>K	1.24
T_2	1.39	0.191	2.29	-13.47	-9.00	22.48	N>P>K	1.75
T_3	1.46	0.197	1.90	- 4.92	-3.58	8.50	N>P>K	2.09
T_4	1.53	0.210	1.50	2.65	3.38	-6.03	K>N>P	2.07
T_5	1.60	0.200	2.10	-3.42	-7.49	10.91	P>N>K	2.66
T_6	1.79	0.180	1.62	13.18	-9.64	-3.55	P>K>N	2.44
T_7	1.52	0.204	1.65	0.27	0.21	-0.48	K>P>N	2.83
T_8	1.39	0.168	2.49	-14.05	-19.03	33.08	P>N>K	2.94
T_9	1.75	0.165	1.29	22.32	-8.51	-13.81	K>P>N	2.36
T_{10}	1.43	0.182	2.29	-10.54	-12.54	22.82	P>N>K	3.08

S. Em. +/- = 0.23
C. D. (P= 0.05) = 0.66
C. V. (%) = 19.30

In the above example, the maximum yield (3.08 t ha^{-1}) was obtained with 135-65-135 treatment which was also comparable with 120-60-120 (2.94 t ha^{-1}) and 120-60-0 (2.83 t ha^{-1}) treatments. However, the yield of 2.83 t ha^{-1} was recorded upto the point when the negative values of DRIS indices were minimum under 120-60-0 treatment which is a recommended dose of wheat. It would be possible that with further increase in the application of particular element, the imbalance may increase to an extent causing a decrease in the yield or in other words that particular element may be toxic. Thus, the application of DRIS norms to the data show that the diagnosis that result in yield responses can be made as explained by Summer (1981). Comprehensive DRIS norms for major and secondary nutrients in case of corn and wheat (Summer, 1976; Summer, 1977b; Summer, 1981), soybean (Beverly *et al.*, 1986), potato (for N, P, K : Sharma, 1991) and litchi (for micronutrients : Hundal and Arora, 1996) have also been tested and their validity established.

Reading the chart

The use of chart (Fig. 1) to make a diagnosis is illustrated by an example (Table 2, treatment-1). The N, P and K concentration in wheat plant sample on dry matter basis are 1.34, 0.196 and 2.13 per cent, respectively which give : N/P = 6.84, N/K = 0.63 and P/K = 0.09. The nutrient insufficiencies are recorded by convention for the purpose of diagnosis which is done stepwise for each function. The value of N/P lies within the inner circle in the zone of balance situation (i) NPK. The value of N/K lies outside the outer circle in the zone of N deficiency, (ii) N ↓ PK ↑ and that of P/K lies inbetween two the circles i.e. the zone of moderate P deficiency, (iii) NP ↘ K. ↗. After reading the three functions, the remaining element is assigned a horizontal arrow. The final reading then becomes : (iv) N ↓ P ↘ K ↑ , which gives the order of requirements of N, P and K in terms of limiting importance on yield as N > P > K. The order of nutrient requirement matched with chart readings as well as DRIS indices.

Thus, critical value approach to diagnose would not achieve the same success as the DRIS system. The application of most limiting nutrient could result in a yield increase, it usually means that the element is present at an insufficient level in the soil as well. Sometime, situation could arise, where application of most limiting nutrient dose not result in yield increase. This is usually the case when some other factors viz., soil salinity, pH, $CaCO_3$, scarcity of water, unfavourable climate etc. are limiting the uptake of the particular element. Therefore, in making useful recommendations having the highest chances of increasing yield, both soil and plant parameters as well as the modifying influence of weather and cultural practices should be taken into consideration (Beaufils, 1973; Summer, 1977b).

Preliminary DRIS norms for N, P and K in wheat leaves have been found to be useful in diagnosing and ranking the most limiting and excessive major nutrients.

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