DIAGNOSIS OF THE NPK REQUIREMENTS OF SUGARCANE IRRESPECTIVE OF PLANT AGE AND SEASON USING BEAUFILS' SYSTEM (DRIS) — PRELIMINARY OBSERVATIONS

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Abstract

Recently Beaufils published a monograph entitled Diagnosis and Recommendation Integrated System (DRIS) in which he presented complete details of his experimental approach and plant/environment calibration technique for the first time. One of the cardinal points of this diagnostic technique is that it should be applicable to a particular crop grown at any place at any stage of its development. The concepts of this experimental approach and diagnostic technique were originally developed for rubber trees in Vietnam; they were then adapted to maize in the southern part of Africa. After further expansion to potatoes, application of these concepts is now being developed for sugarcane. In this paper preliminary observations on the sensitivity and general applicability of this system to sugarcane are presented. From data on leaf composition and yield obtained from growers in the South African Sugar Industry by means of a survey, a provisional standard chart for the determination of N P K requirements of sugarcane has been established. An evaluation of this chart has been made by application to data obtained either from the literature or the S.A. Sugar Association Experiment Station, Mount Edgecombe. At this early stage it appears that one can reasonably expect an improved sensitivity in the diagnosis of N and P requirements of sugarcane as well as the possibility of diagnosing N P K requirements at any stage of development irrespective of moisture status, season and variety.

Introduction

Recently Beaufils[3] published his Diagnosis and Recommendation Integrated System (DRIS) for determining the fertilizer and other treatments required by a given crop in order to enhance the chances of either obtaining a higher yield or maintaining higher yield at lower cost. Because the approach of this system is holistic and differs from the classical, it is bound to take time before it is generally accepted.

One of the basic advantages of this method is that once a standard set of norms based on foliar composition has been developed for a given crop, they are applicable to that particular crop grown at any place and at any stage of its development.

The purpose of this paper is to present further observations dealing with the application of this system to sugarcane. Previous observations on the application of DRIS to sugarcane actually indicated that predictions of yield responses to P fertilizers were more reliable and sensitive than the threshold approach.[4]

Brief outline of DRIS

Roughly speaking, DRIS represents a general scheme of experimentation and calibration based on principles developed from research in soil fertility and plant nutrition.

Firstly it differs rather radically from the classical approach to field experimentation. In a classical field experiment used for soil fertility evaluation purposes, a number of plots are studied at a given site, whereas in the DRIS approach, actual production lands and/or small experimental plots are studied throughout the areas in which the particular crop is grown. At each site, as many plant/environment yield factors as are capable of expression are recorded as well as yield. These factors include soil composition, plant composition and environmental variables as well as farming practices.

The interrelationship between these factors, as well as their relationship with yield are studied irrespective of whether any particular factor is known to have an influence on yield. This is essential as any one of these yield factors may become limiting in a particular case; therefore, to obtain as complete a picture as possible all factors must be studied so that the information can be used for diagnostic and recommendation purposes.

Secondly, it is essential to characterise all reactions which take place from the time of applying a given treatment to the time of harvest. The components which constitute the intermediates in the reaction

$$\text{soil treatment} \rightarrow f(\text{yield})$$

are illustrated below:

(i) Soil properties → f_1(plant response) → φ_1(yield)
(ii) Climatic conditions → f_2(plant response) → φ_2(yield)
(iii) Farming practices → f_3(plant response) → φ_3 (yield)
(iv) Soil treatments + soil properties = f_4 (soil response) etc.
(v) Soil response + climatic conditions + farming practices = f_5(plant response) etc.
(vi) Plant response (Σ internal characters) → φ (yield)

The DRIS system characterises the above six components in terms of indices which are derived as comparable functions of yield. Not only do these indices allow one to classify yield factors in order of limiting importance, but they also give an indication of the intensity with which the plant or soil requires a given nutrient. Because these indices rank the yield factors in order of limiting importance, they automatically incorporate the concept of balance into the system. These indices for soil, plant and environmental parameters constitute a set of calibrated norms which can be used for diagnostic and recommendation purposes.

The indices for soil, climatic conditions and farming practices indicate what is offered and not offered to a particular plant at a given site. These indices are calibrated in terms of the nature and amount of a specified treatment which is required.

On the other hand, the plant indices to which this paper will be confined simply indicate the nature and degree of nutrient balance in the plant from which one can establish what is demanded by the plant at a given site. Plant indices considered on their own do not give an automatic indication of the nature and amount of a particular element which must be added to the soil, as indeed, plant response is a function of soil properties and soil response to treatments (Beaufils[3]).

Given a target yield under specified economic conditions the DRIS calibration system can be used to simultaneously bring the largest number of plant and environmental characters as close as possible to the established optimum values.

It is therefore the correct and judicious use of the complete set of calibrated indices which will enable one to establish the most appropriate practice or treatment for each particular case under consideration. Furthermore, although the application of the most appropriate treatment will increase the chances of obtaining a higher yield or production efficiency, one should bear in mind that uncontrollable factors can always play a part in limiting the chances of success.

This brief outline is intended to summarise the entire experimental system for the calibration of plant, soil and environment and quite clearly cannot do justice in the limited space available.

However, the accent of the remainder of the paper will focus on the sensitivity and general applicability of the plant calibration component to sugarcane. To illustrate this a few examples have been selected from the files of the S.A. Sugar Association Experiment Station at Mount Edgecombe and the literature.[6] The provisional chart for NPK which will be tested has been compiled from independent information made available by various South African sugar companies and growers.

Provisional chart for diagnosing the NPK requirements of sugarcane

The original chart of this type was established in 1956 for rubber in Vietnam by Beaufils[1,2] who showed that it could be used to obtain both qualitative and quantitative expressions for the order of NPK requirements of the plant in terms of comparable functions of yield. DRIS charts for other nutrients and other crops such as maize, sugarcane, potatoes and rye-grass have subsequently been established at the University of Natal and the South African Sugar Association Experiment Station.

A provisional chart for obtaining qualitatively the NPK requirements of sugarcane is given in Figure 1.

A qualitative reading of this chart can be done by using arrows in the following conventional manner: horizontal → for values within the inner circles of the chart, diagonal ↗ ↘ for values between the two circles and vertical ↑ ↓ for values found beyond the outer circle.

The way in which this chart is used will be illustrated by means of an example. Assume that the following values are obtained from the analysis of the third leaf blade of sugarcane:

N %	P %	K %	N/P	N/K	K/P
2,34	0,39	1,17	6,0	2,0	3,0

Because an excess of one plant nutrient corresponds to a shortage of another, by convention only insufficiencies are recorded for the purpose of diagnosis and this is done stepwise for each function. Identical diagnoses are obtained by considering either excesses or insufficiencies or both.

The value of the function N/P lies in the zone of N insufficiency giving:

(i) N ↓ P K

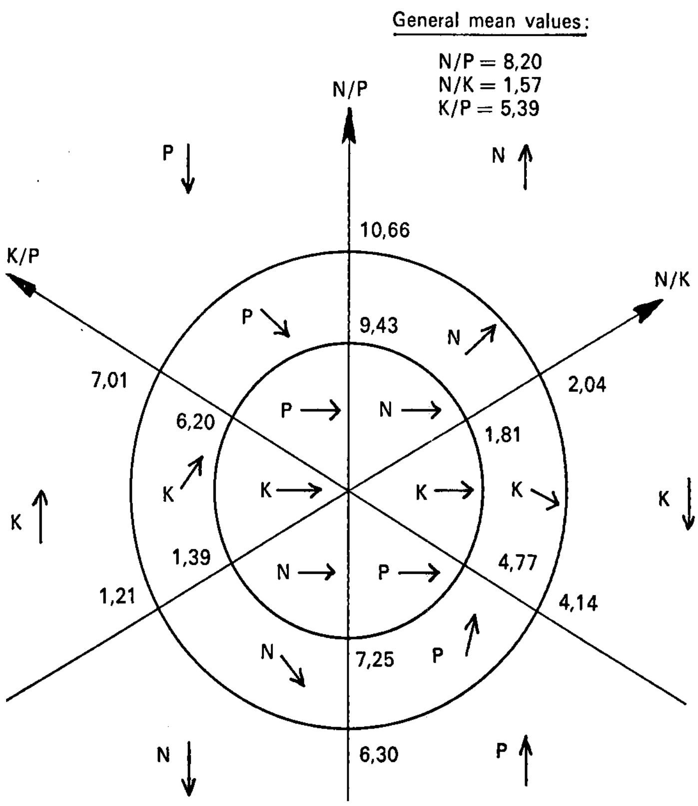

FIGURE 1 Provisional DRIS chart for obtaining the qualitative order of requirement for NPK in sugarcane. (General mean values are: N/P = 8,20, N/K = 1,57, K/P = 5,39).

while that of N/K lies between the two circles adding a tendency to K insufficiency

(ii) N ↓ P K ↘

and that of K/P lies in the zone of K insufficiency giving

(iii) N ↓ P K ↘ ↓

Once the three common functions have been read, the remaining character is assigned a horizontal arrow.

The final reading then becomes:

(iv) N ↓ P → K ↓ ↘

which gives the order of requirements for NPK in terms of limiting importance on yield — viz.:

K > N > P

Full details of how this chart is obtained and how diagnostic indices are calculated are presented in a monograph by Beaufils.[3] An index value essentially represents the distance by which any particular character deviates from its optimum position in respect of balance with other characters.

Application of the diagnostic indices to experiments with sugarcane

(a) Testing sensitivity in diagnosing NPK requirements

Two crops (first and second ratoon) from a 3^3 NPK factorial experiment will be used for this purpose. Yield, leaf composition and transformed indices[3] in relation to NPK treatments are presented in Tables 1 and 2 for the two ratoons respectively.

Before studying the data in these tables the reservation made above that plant response is a function of soil properties and soil response to treatments, should be borne in mind. Therefore considering plant indices alone, one cannot expect to obtain

TABLE 1

Application of Beaufils's indices to the first ratoon of a 3³ NPK factorial experiment with sugarcane on a Clansthal sand at Tongaat (planted with Co 301 on 1/11/52, cut on 10/10/54, leaf sampled on 17/3/55, cut on 6/8/56)†

Treatments NPK	Leaf composition (dry matter basis) N%	P%	K%	Transformed indices N	P	K	Order of requirements for NPK	Yield on particular plot t cane/ha	Yield recorded as a result of applying most limiting nutrient t cane/ha	Yield difference to be credited to DRIS diagnosis t cane/ha	Yield difference to be credited to threshold value diagnosis t cane/ha
011	**1,77***	0,27	1,15	−40	40	−36	N > K > P	56,74	77,84	21,10 (N)	21,10 (N)
102	2,11	**0,25**	1,33	3	− 3	− 3	P = K > N	85,77	80,19	− 5,58 (P)	0,00
220	2,30	0,28	**0,85***	109	114	−114	K > N > P	55,27	99,30	44,03 (K)	44,03 (K)
212	2,04	**0,24***	1,24	8	0	− 8	K > P > N	82,25	101,94	19,69 (P)	0,00
000	2,00	0,27	**0,98***	33	71	−71	K > N > P	81,88	132,89	51,01 (K)	51,01 (K)
110	2,11	0,28	**1,01***	39	71	−71	K > N > P	72,99	77,84	4,85 (K)	4,85 (K)
201	2,19	**0,25***	1,52	− 3	−21	21	P > N > K	71,52	82,39	10,87 (P)	0,00
121	2,12	0,26	**1,14***	27	33	−33	K > N > P	62,77	90,85	28,08 (K)	0,00
022	**1,93***	0,28	1,16	−21	43	−43	K > N > P	79,82	90,85	11,03 (N)	0,00
002	**1,72***	0,22	1,30	−26	− 6	26	N > P > K	46,82	85,77	38,95 (N)	38,95 (N)
120	2,02	0,26	**0,85**	66	92	−92	K > N > P	91,14	62,77	−28,37 (K)	−28,37 (K)
222	1,98	0,25	1,39	−14	0	14	N > P > K	101,94	—	—	—
010	**1,73**	0,29	1,16	−57	57	−45	N > K > P	73,45	72,99	− 0,46 (N)	− 0,46 (N)
101	1,97	0,23	**1,08***	25	15	−25	K > P > N	84,30	85,77	1,47 (K)	0,00
200	2,17	0,23	**1,01**	56	12	−56	K > P > N	74,97	71,52	− 3,45 (K)	− 3,45 (K)
021	**1,60***	0,33	1,17	−102	102	−54	N > K > P	56,30	62,77	6,47 (N)	6,47 (N)
211	2,12	0,28	**1,18**	9	39	−39	K > N > P	82,39	82,25	−0,14 (K)	0,00
112	**2,00***	0,25	1,28	− 6	6	− 6	K = N > P	80,19	82,25	2,06 (N)	0,00
012	**1,80***	0,24	1,22	−16	16	0	N > K > P	50,49	80,19	29,70 (N)	0,00
202	2,28	**0,23***	1,38	29	−29	9	P > K > N	69,97	82 25	12,28 (P)	0,00
210	2,17	0,26	**1,07***	47	45	−47	K > P > N	77,91	82,39	4,48 (K)	0,00
221	2,07	0,24	**1,14***	24	12	−24	K > P > N	99,30	101,94	2,64(K)	0,00
111	2,10	0,25	**1,19***	19	15	−19	K > P > N	77,84	80,19	2,35 (K)	0,00
122	**1,99***	0,28	1,53	−29	21	29	N > P > K	90,85	101,94	11,09 (N)	0,00
020	1,70	0,34	**1,00***	−84	120	−120	K > N > P	50,94	56.30	5,36 (K)	5,36 (K)
100	1,89	0,23	**1,15***	6	10	−10	K > N > P	77,54	84,30	6,76 (K)	0,00
001	**1,75**	0,24	1,25	−20	20	12	N > K > P	132,89	84,30	−48,59 (N)	−48,59 (N)
							Difference in yield over all plots:			+227,68	+90,90

TABLE 2

Application of Beaufils's indices to the second ratoon of a 3³ NPK factorial experiment with sugarcane on a Clansthal sand at Tongaat (cut 6/8/56, leaf sampled 11/1/57, cut on 22/5/58)†

Treatments NPK	Leaf composition (dry matter basis) N%	P%	K%	Transformed indices N	P	K	Order of requirements for NPK	Yield on particular plot t cane/ha	Yield recorded as a result of applying most limiting nutrient t cane/ha	Yield difference to be credited to DRIS diagnosis t cane/ha	Yield difference to be credited to threshold value diagnosis t cane/ha
011	**1,58***	0,41	1,09	−168	168	−144	N > K > P	32,49	71,44	38,95 (N)	38,95 (N)
102	2,41	**0,28***	1,20	42	30	−42	K > P > N	44,54	80,26	35,72 (P)	0,00
220	2,51	0,34	**0,60***	234	294	−294	K > N > P	52,41	103,78	51,37 (K)	51,37 (K)
212	2,41	**0,27***	1,28	31	9	− 31	K > P > N	72,47	92,83	20,36 (P)	0,00
000	2,00	0,26	**0,80***	78	108	−108	K > N > P	58,51	76,81	18,30 (K)	18,30 (K)
110	2,22	0,33	**0,75***	99	193	−193	K > N > P	52,85	71,44	18,59 (K)	18,59 (K)
201	2,39	0,27	**0,83***	126	102	−126	K > P > N	59,61	70,71	11,10 (K)	11,10 (K)
121	2,41	0,35	**0,93***	69	145	−145	K > N > P	56,60	90,26	33,66 (K)	33,66 (K)
022	**1,75***	0,41	1,02	−123	167	−167	K > N > P	55,57	90,26	34,69 (N)	34,69 (N)
002	**1,68***	0,21	1,04	0	12	− 12	K > N > P	23,52	44,54	21,02 (N)	21,02 (N)
120	2,41	0,41	**0,64**	150	336	−336	K > N > P	72,99	56,60	−16,39 (K)	−16,39 (K)
222	2,46	0,36	1,19	18	88	− 88	K > N > P	92,83	—	—	—
010	1,87	0,27	**0,89**	24	90	− 90	K > N > P	62,33	32,49	−29,84 (K)	−29,84 (K)
101	2,12	0,29	**1,11**	15	57	− 57	K > N > P	69,24	44,54	−24,70 (K)	0,00
200	2,38	0,28	**0,61***	224	216	−224	K > P > N	58,58	59,61	1,03 (K)	1,03 (K)
021	1,85	0,33	**0,95***	− 33	123	−123	K > N > P	31,97	55,57	23,60 (K)	23,60 (K)
211	2,53	0,30	**1,01**	91	87	− 91	K > P > N	76,88	72,47	− 4,41 (K)	− 4,41 (K)
112	**2,39**	0,31	1,42	0	24	− 24	K > N > P	80,26	72,47	− 7,79 (N)	0,00
012	**1,60***	0,24	1,15	− 36	36	0	N > K > P	30,80	80,26	49,46 (N)	49,46 (N)
202	2,50	**0,28***	1,29	36	12	− 36	K > P > N	70,71	72,47	1,76 (P)	0,00
210	2,53	0,29	**0,70**	186	178	−186	K > P > N	80,41	76,88	− 3,53 (K)	− 3,53 (K)
221	2,44	0,38	**1,26**	− 6	88	− 88	K > N > P	103,78	92,83	−10,95 (K)	0,00
111	2,27	0,29	1,05*	48	70	− 70	K > N > P	71,44	80,26	8,82 (K)	0,00
122	**2,51***	0,39	1,91	− 43	43	15	N > K > P	90,26	92,83	2,57 (N)	0,00
020	1,77	0,27	**0,68***	60	158	−158	K > N > P	26,83	31,97	5,14 (K)	5,14 (K)
100	1,99	0,25	**0,92***	51	67	− 67	K > N > P	63,65	69,24	5,59 (K)	5,59 (K)
001	1,73	0,24	**1,06**	− 15	31	− 31	K > N > P	76,81	23,52 69,24	−53,29 (K)	− 7,57 (N)
							Difference in yield over all plots:			+230,83	+250,76

* The values of N, P or K (on dry matter basis) corresponding to a diagnosed requirement by the DRIS method appear in bold figures. An asterisk indicates that a positive yield response was obtained.

† Data kindly supplied by the South African Sugar Association Experiment Station, Mount Edgecombe.

an automatic indication of the nature and amount of a particular element which must be added to the soil in every case. Using each treatment combination (plot) to represent a field situation, a diagnosis has been carried out using the DRIS system as well as the threshold values proposed for sugarcane, viz.: 1,80% N, 0,19% P and 1,05% K. Having made a diagnosis for a particular plot, the treatment combination incorporating the required nutrient is selected to establish whether a yield response would have been obtained or not. The yield for this plot is presented in the tenth column of Tables 1 and 2. For example, in the first ratoon on plot 011 where the yield was 56,74 tc/ha, DRIS diagnosis shows that the order of plant requirement is N > K > P. By selecting plot 111 in which N has been applied (as diagnosed), it is possible to state that a yield response would have been obtained by applying N to plot 011 because the yield has increased to 77,84 tc/ha giving a net response of 21,10 tc/ha to N application. Concomitantly the value of N index has increased from — 40 in plot 011 to + 19 in plot 111 where K has now become the most required nutrient. It should be noted that a nutrient can, even after its application to soil, remain the most required plant nutrient; this is usually the case when either the amount applied is insufficient and/or the nature, form, date, etc., of the treatment is not appropriate. Using threshold values given for the particular conditions of these experiments it is also possible to diagnose a marginal requirement for N on plot 011.

This process is then repeated taking each plot as an origin for diagnosis by both methods. In the few cases where the most required nutrient could not be selected because it was already present in the treatment combinations at level 2, the second most required nutrient was substituted. The net result is reflected in the last two columns on the right of the Tables 1 and 2 which give the net yield response to treatment diagnosed by each method (the element responsible for the response appears in parenthesis). Totalling these responses over all treatments shows that DRIS diagnosis would lead to greater benefits over both ratoons than that based on threshold values.

From Tables 1 and 2 it can be seen that there are a number of cases in which requirement for an element is diagnosed by DRIS and a positive yield response obtained when it is supplied, despite the fact that the element concentration in the leaf is well above the threshold value. This emphasises the point that balance is certainly more important in plant nutrition than the actual level of a nutrient in the leaf.

The sensitiveness of the respective diagnostic systems are compared for each nutrient in Table 3.

TABLE 3

Comparison of yield response to applied nutrients diagnosed by DRIS and threshold values respectively over all plots in two ratoons of a 3^3 N P K factorial experiment

Nutrient applied	DRIS positive response		Threshold value positive response	
	No.	t cane/ha	No.	t cane/ha
N	12	210,25	7	154,02
P	6	95,10	0	0,00
K	20	153,16	13	187,64
Total	38	458,51	20	341,66

The indications are that at this stage the DRIS system is superior in diagnosing N and P requirements while the threshold values give a slightly better diagnosis for K requirement in terms of response in tons cane per hectare but not in the number of cases diagnosed.

Despite the fact that threshold values may perform as well as the DRIS system for diagnosing the K requirement of sugarcane it should be borne in mind that threshold values cannot be used at any stage of plant development whereas the DRIS system can, as will be shown below.

(*b*) *Testing the effect of plant age, season, cultivar, and moisture stress on diagnosis of NPK requirements of sugarcane*

Gosnell and Long[6] studied the effect of a number of plant and external factors on foliar composition. Their data will largely be used to show the general applicability of the DRIS system of diagnosis to sugarcane at any stage of growth. They designed an experiment in which it was possible to separate the effects of age of cane and season on foliar composition. Results from this experiment together with calculated indices are presented in Tables 4 and 5.

TABLE 4

Effect of age on leaf composition and diagnosis (data from Gosnell and Long[6])

Age in months	Leaf composition (dry matter basis) N%	P%	K%	Transformed indices N	P	K	Order of requirement for NPK
1	2,70	0,27	1,65	30	−30	12	P > K > N
2	2,22	0,23	1,52	3	−25	25	P > N > K
3	1,99	0,21	1,48	0	−46	46	P > N > K
4	1,86	0,20	1,50	−21	−59	59	P > N > K
5	1,78	0,18	1,48	−15	−79	79	P > N > K
6	1,68	0,18	1,42	−25	−69	69	P > N > K
7	1,68	0,17	1,46	−24	−88	88	P > N > K
8	1,68	0,17	1,44	−21	−85	85	P > N > K
9	1,62	0,17	1,50	−42	−94	94	P > N > K
10	1,56	0,16	1,40	−33	−91	91	P > N > K

TABLE 5

Effect of season on leaf composition and diagnosis (data from Gosnell and Long[6])

Season	Leaf composition (dry matter basis) N%	P%	K%	Transformed indices N	P	K	Order of requirement for N P K
Aug.	2,15	0,22	1,52	12	−44	44	P > N > K
Sept.	2,04	0,20	1,50	12	−58	58	P > N > K
Oct.	2,08	0,20	1,48	21	−55	55	P > N > K
Nov.	1,95	0,22	1,46	−15	−31	31	P > N > K
Dec.	1,84	0,22	1,51	−39	−41	41	P > N > K
Jan.	1,90	0,19	1,45	0	−62	62	P > N > K
Feb.	1,87	0,18	1,37	18	−62	62	P > N > K
Mar.	1,69	0,18	1,51	−39	−83	83	P > N > K
April	1,58	0,17	1,52	−54	−98	98	P > N > K

Irrespective of age of cane or season it can be clearly seen that the cane under consideration had the greatest requirement for P followed by N with only one exception. In other words using DRIS it is possible to make a diagnosis irrespective of age or season because their natural influences on tissue composition are overshadowed by the dominant P and secondary N unsatisfied requirements.

Had the threshold values of Gosnell and Long[6] (1,8% N, 0,18% P and 1,10% K) been used for diagnosis in these two cases, the P requirement of the crop would have only been detected from the seventh month onward (Table 4) and only in April (Table 5) whereas the DRIS system predicted P requirement at all seasons and ages. This is clearly an advantage of the latter.

According to Gosnell and Long[6] it is generally accepted that moisture stress affects foliar composition and consequently samples should only be taken when moisture is not limiting.

TABLE 6
Effect of irrigation on leaf composition and diagnosis (data from Gosnell and Long[6])

Treatment water applied mm	Pan factor	Leaf composition (dry matter basis)			Transformed indices			Order of requirement for N P K
		N%	P%	K%	N	P	K	
610	0,37	1,95	0,218	1,25	11	−11	9	P>K>N
914	0,53	1,84	0,222	1,37	−24	−24	24	P=N>K
1219	0,68	1,92	0,222	1,39	−12	−24	24	P>N>K
1321	0,84/ 0,60	1,91	0,228	1,39	−18	−20	20	P>N>K
1524	0,84	1,92	0,231	1,39	−18	−20	20	P>N>K
1770	1,00	1,96	0,232	1,39	−12	−18	18	P>N>K

Using data from one of their experiments in which six irrigation treatments based on various pan factors were applied, it is clear from Table 6 that moisture stress has had little effect on diagnosis by the DRIS method. In all but the most severely stressed plots, the order of requirement for N, P and K was the same. Even under the most severe stress, P was still the most required nutrient but the position of K and N had been exchanged. Using threshold values for diagnosis would indicate that the cane was in a satisfactory state of nutrition. One of the problems implicit in using the threshold value concept is that one is unable to detect excesses and imbalances.

TABLE 7
Effect of variety on leaf composition and diagnosis (data from Gosnell and Long[6])

Variety	N%	P%	K%	Transformed indices			Order of requirements for N P K
				N	P	K	
Co 1001	1,92	0,172	1,56	12	−100	100	P > N > K
NCo 376	1,82	0,170	1,46	6	− 88	88	P > N > K
N52–219	1,78	0,140	1,58	36	−156	156	P > N > K
M31–45	1,77	0,165	1,70	−30	−132	132	P > N > K
Co 462	1,74	0,162	1,49	− 2	−104	104	P > N > K
Pindar	1,66	0,170	1,58	−45	−107	107	P > N > K
CB40–77	1,54	0,155	1,80	−93	−167	167	P > N > K
N55–805	1,73	0,172	1,43	− 9	− 81	81	P > N > K

The effect of variety on leaf composition is presented in Table 7 from which it can be seen that DRIS diagnosis consistently shows that the order of requirement is P > N > K illustrating that this system can be used irrespective of variety. Using the threshold values proposed by Gosnell and Long[6] one would arrive at essentially the same picture without the possibility of ranking the order in which the nutrients are required.

Because plant development is a dynamic process, it is essential to remember that leaf composition reflects only the resulting effects of the conflicting interferences between every plant external and internal factor at the time of sampling (Beaufils[3]). Therefore, as the plant develops gradually, its specific requirements are expected to vary and the predominant influence of a factor, say soil P shortage or unavailability can, depending on its degree of intensity, be overcome by much stronger effects provoked by the particular changes in plant and environmental conditions at a given site.

For these reasons, one cannot expect a diagnosis from plant tissue composition to always remain immutable throughout the life of the plant but on the contrary to consistently indicate the nature of these predominant influences and their degree of limitation of yield at the time of observation (sampling).

Conclusions

Although no definite conclusions can be made because of the tentative nature of the DRIS diagnostic norms for sugarcane, it nevertheless appears that one can reasonably expect the DRIS system to give an improved sensitivity in the diagnosis of N and P requirements of sugarcane as well as the possibility of diagnosing NPK requirements irrespective of plant age, season, variety and drought stress.

The technique used in this paper for the interpretation of the two 3^3 factorial experiments has only been employed to compare two dissimilar diagnostic approaches. Past experience on other crops has shown that complementary knowledge of the conditions offered to the plant (environmental calibration) will further improve the diagnostic precision and sensitivity of the data in this paper.

Further research work is under way to confirm these observations and expand this type of calibration to climatic, soil, field practice and treatment yield factors as well as for the other essential elements.

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REFERENCES

1. Beaufils, E. R. (1956). Mineral equilibrium in the foliage and latex of *Hevea brasiliensis*. Ann. INRA. Annales Agronomiques 2,205.
2. Beaufils, E. R. (1957). Research for rational exploitation of *Hevea brasiliensis* using a physiological diagnosis based on the mineral analysis of various parts of the plant. Fertility 3: 27.
3. Beaufils, E. R. (1973). Diagnosis and Recommendation Integrated System (DRIS). A general scheme for experimentation and calibration based on principles developed from research in plant nutrition. Soil Science Bull. No. 1. University of Natal.
4. Experiment Station—South African Sugar Association, Annual Report 1973/74, p. 27.
5. Experiment Station—South African Sugar Association, Annual Report, 1971/72 p. 20.
6. Gosnell, J. M. and Long, A. C. (1971). Some factors affecting foliar analysis in sugarcane. SASTA Proc. **45**: 217-232.