ON THE FERTILIZATION OF SUGAR CANE [1])

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Summary

Soil and leaf analyses, combined with field experiments, indicate that the fertilization of the sugar cane crops in Indonesia is in many cases inadequate.

It was calculated that a sugar cane crop removes an average of 100 kg N, 100 kg PO_4, *350 kg K*, 30 kg Ca and 30 kg Mg per annum per ha from the soil, whereas the annual supply of the area under investigation was : 110–140 kg N, 100 kg PO_4, *6 kg K*, 55 kg Ca, 7 kg Mg and 15 kg Na per ha.

It is demonstrated that the rendement [2]) value depends on the uptake, and consequently the content of N, P, and K in the cane crop. Since the uptake of K is greatly affected by the uptake of Mg and Ca, it is evident that the problem of sugar production is very complex.

The rendement level (see tables 4 and 5) is determined by the concentration ratios of the elements in particular, and not by the absolute content in the leaf. When the N content in the leaf is sufficiently high, a relationship exists between the rendement and the K/PO_4 ratio in the leaf (see fig. 2) ; there will be an optimum value for this ratio. If the N content and the PO_4 content are adequate, a direct relationship can be noticed between the yield and the K content of the leaf ; there will likewise be a correlation between the $K/PO_4 + N$, K/PO_4 and K/N ratios and the rendement. When the K content in the leaf is adequate, there will be a relationship between the rendement and the PO_4/N ratio in the leaf (see fig. 1) ; the optimum value is approximately 0,215.

From table 4 it can be concluded that nitrogen has the greatest effect on cane production. On the other hand it tends to decrease the sugar content. In order is combine high cane yields with high sugar yields, great attention should be plaid to P and K fertilization.

The results obtained from leaf analyses of sugar cane crop grown on simply designed experimental fields make it possible to give advice on what is the most adequate fertilization.

This investigation proves once again that fertilization experiments can only give definite results when they are combined with leaf analyses. It is also evident that the mineral composition of the crop is a better guide to the fertility level of the soil than soil analysis.

Introduction

For various reasons sugar production in Java (Indonesia) is tending to fall. One reason is the unbalanced fertilization of the cane. When, then, the Tasikmadoe (Perusahaan Perkebunan Republik Indonesia, Solo) sugar factory afforded us an opportunity of investigating the matter we gratefully accepted the invitation.

Inspection of the crop on the area planted by the factory showed that the well-known symptoms of potassium deficiency (leaf margins and tops discoloured yellow, and red spots on the midrib ; see v. d. Honert, 1932) were practically everywhere in evidence. As the land had never been given a potash dressing, an obvious idea was that a dressing with a potassium salt would lead to the desired improvement in yield ; but when enquiries were made it was found that experiments with potash dressings carried out by the Experiment Station for the Java Sugar Industry from 1931 to 1934 had also failed to give reliable increases in the yield. In certain cases a potash dressing did give a higher yield when the amounts of phosphate and nitrogen applied were in-

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2) % sugar of cane weight.

creased at the same time. Consequently the problem was more complicated than it appeared.

In order to gain some information on the fertilization problems of Tasikmadoe, preliminary investigations were carried out, beginning with a soil and moisture survey and ending with simple fertilization tests combined with crop analyses. Although the investigation was kept as simple as possible, results were obtained which are sufficiently interesting to warrant their inclusion here.

In view of the abundance of previous fertilization trials we shall not attempt attempt to summarise them here. Reference may be had to EDELMAN (1941), v. DILLEWIJN (1952), HAUCK and DICKINSON (1954), and BURR, et all (1957).

IRRIGATION, FERTILIZATION AND SOIL TYPES OF TASIKMADOE

In order to gain some idea of the nutritional status of a crop in a particular area, information should be available on the fertilization, the composition of the irrigation water, and the physical and chemical condition of the soil, as well as on the amounts of nutrient elements which are removed with the crop when the field is harvested.

As regards the latter, it will be immediately clear that these amounts depend of the fertility-level of the soil, the cane yield, and the variety. The observations made by KALIS (1929) and HONIG (1935), may afford some idea of this. Thus HONIG found that a crop of the POJ 2878 clone, 60-80 kg N, 40-180 kg PO_4, 120-540 kg K, 15-40 kg Ca and 13-40 kg Mg removed from the soil per hectare. Our own observations of clones POJ 2961 and POJ 3061 gave values lying between these extremes, although the amount of nitrogen removed was 120 kg per hectare. The amount of sodium in the cane proved to be negligible. As an approximation, it may be assumed that an average cane harvest removes from the soil 100 kg N, 100 kg PO_4, 350 kg K, 30 kg Ca and 30 kg Mg per hectare.

The fertiliser supply at Tasikmadoe consists of 550-700 kg ammonium sulphate and 150 kg triple superphosphate per hectare. As stated above, potassic fertilisers are not used. The water with which the area is irrigated, is supplied from two basins (Delingan and Lalung) and from the river Sanin. In order to gain an idea of the amounts of nutrients supplied with this water, both the water supplied and drained off was sampled and analysed. Of the river Sanin only the supply water was tested. The results are presented in Table 1.

Table 1 Composition of the irrigationwater in mg/l (in- and outlet) [1]).

Element	Basin Delingan		Basin Lalung		River Sanin	Mean	
	inlet	outlet	inlet	outlet	inlet	inlet	outlet
N	nil	nil	nil	nil	nil	nil	nil
PO_4	12.86	10.85	6.97	6.58	13.28	9.91	8.71
K	3.15	2.70	2.86	3.00	2.88	3.00	2.85
Ca	14.13	9.84	11.35	10.83	13.72	12.74	10.33
Mg	2.89	2.59	2.00	nil	1.49	2.44	1.24
Na	6.99	6.24	7.13	6.64	7.41	7.06	6.44

[1]) The values represent the sum of the amounts, in solution and in the silt and clay carried with the water (estimated by extraction with 25 % HCl).

According to information given by the factory, some 4 x 10^6 litres of water are supplied per hectare per annum, about 2 x 10^6 litres running off. The amounts of nutrients supplied with the irrigation water are therefore a negligible amount of N, 22 kg PO_4, 6 kg K, 30 kg Ca, 7 kg Mg and 15 kg Na per hectare per season. When we add to these amounts the nutrient elements present in the fertilisers, the cane is supplied with 110-140 kg N, 100 kg PO_4, 6 kg K, 55 kg Ca, 7 kg Mg and 15 kg Na. If we assume that these amounts are entirely taken up by the cane, it may be concluded that the supply of N, Ca and Na is sufficient, that the PO_4 supply is barely sufficient, and that the supply of K in particular is entirely inadequate. The N supply seems particularly adequate when it is remembered, that the natural enrichment of the soil (N fixation) may be considerably in the tropics (up to 100 kg N per hectare. BAARS, 1950). The PO_4, K and Mg deficits must therefore be made up by the soil, but in view of the large amounts of K required by the cane, this is a particularly difficult task in the case of potassium.

The soils planted by the Tasikmadoe factory belong to the following groups.

1) Brown, andesitic, lateritic soils (DAMES, 1955), belonging to the well-developed and well-drained soils on tertiary and quaternary volcanic products of the Lawu. These are the "reddish-brown latosols". The Gajadompo and Popongan sectors (250—300 metres above sea-level) lie on the soils. A profile of Gajadompo is as follows :

0—20 cm	Dark reddish-brown (5YR3/3) friable, loose clay, pH 5.61 ; C : 1.01 %.
20—35 cm	Dark reddish-brown (5YR3/4) clay with nut structure. Contains iron and iron manganese concretions. pH 5.63 ; C : 0.52 %.
35—75 cm	Dark reddish-brown (5YR3/4) loose clay with nut structure. pH 5.68 ; C : 0.42 %.

The PO_4 contents of the horizons (determined by extraction with 25 % HCl) are 0.170 %, 0,186 % and 0 198 % respectively. The K contents are 0.069 %, 0.071 % and 0.071 % respectively.

The Popongan soil has a similar profile, but the concretion stratum is absent. The soil is younger and slightly, less clayey ; dark patches of ash and sand are found everywhere. The pH varies from 5.47 in the 40 cm thick top layer to 6.16 in the underlying horizon (40—75 cm). The C contents are 0.69 % and 0.09 % respectively, the PO_4 contents 0.079 % and 0.095 %, and the K contents 0.049 % and 0.066 %.

2) Black, andesitic margalite soils (DAMES, 1955) in the plain (100 metres above sea-level), formed on volcanic products of the Lawu. These are the "tuff margalites" of which the genesis has been adequately explained by EDELMAN (1946). The Kebak sector is situated on this soil. A typical profile of these poorly drained soils is as follows :

0—20 cm	Dark grey (7.5YR4/0) heavy clay with a nut to block structure. pH 6.66 ; C : 1.75 %.
20—45 cm	Grey (7.5YR5/0) sticky clay with a prismatic structure. pH 6.81 ; C : 1.19 %.
45—70 cm	Grey (7.5YR5/0) sticky clay with $CaCO_3$ concretions. pH 7.18 ; C : 0.37 %.

The PO_4 contents are 0.017 %, 0.072 % and 0.103 % respectively, and the K contents 0.034 %, 0.053 % and 0.062 % respectively.

3) Whitish-grey loams belonging to the bleached earths (DAMES, 1955) and

formed from alluvial deposits derived from young Lawu products. They are situated at about 90 metres above sea-level and have a high water table. Closer inspection shows that these soils have the properties of salt soils, viz. Solonetz soils with a nut structure (VILENSKI, quoted by JOFFE, 1949). A certain migration of clay and organic material is to be observed, so that a fuller description might be "weakly solodized solonetz". The Waroe sector is situated on this soil. A typical profile is :

0–14 cm	Greyish-brown (2.5Y5/2) sandy loam with a nut structure and brown mottlings. pH 8.52 ; C : 1.52 %.
14–27 cm	Grey (5Y5/1) sandy clay with a nut to prism structure. Brown mottlings. pH 8.32 ; C : 0.77 %.
27–45 cm	Greyish-brown (2.5Y5/2) clay with light-grey (10YR7/2) mottlings. Weakly prismatic and sticky. pH 8.43 ; C : 1.19 %.
45–65 cm	Light grey (10YR6/1) sticky clay with bluish (2.5Y5/0) mottlings. Massive. pH 8.28 ; C : 0.75 %.
65–75 cm	Light grey (5Y6/1) sticky clay. Slight effervescence with HCl in the lowest 5 cm. Grey (2.5Y6/0) mottlings. pH 8.31 ; C : 0.75 %.
+75 cm	Light grey (10YR7/2) fine sandy loam with grey (2.5Y6/0) mottlings. Contains $CaCO_3$ concretions. pH 8.18 ; C : 0.16 %.

The PO_4 contents of 0–27 cm and 27–45 cm are 0.060 % and 0.056 %, and the K contents 0.037 % and 0.037 %.

4) Between the tuff margalites at an altitude of 100 metres and the reddish-brown latosols at an altitude of 250 to 300 metres lie soils which are transition forms in the sense that the higher the soil the deeper is the grey colour of the product. This is connected with the water table (see EDELMAN, 1946). The Alastoewo and Tegalgede sectors are situated on these soils. A profile of the Tegalgede sector (altitude 200 metres) has the following appearance :

0– 9 cm	Dark grey (10YR4/1) friable and loose clay. pH 6.69 ; C : 5.98 %.
9–17 cm	Dark brown (7.5YR4/2) clay with a nut structure. Crumbles fairly easily. pH 6.52 ; C : 2.60 %.
17–48 cm	Dark reddish-grey (5YR4/2) clay with a weakly prismatic structure. Compact and refractory. pH 6.62 ; C : 1.68 %.
48–60 cm	Reddish-brown (5YR5/4) clay with a weakly prismatic structure. Clay films on the aggregates. Refractory. pH 6.84 ; C : 1.64 %.
60–80 cm	Reddish-brown (5YR5/4) clay with a blocky to prismatic structure. Grey (7.5YR5/2) patches. Black iron manganese concretions. pH 7.08 ; C : 0.67 %.
+80 cm	Reddish-yellow (7.5YR6/8) sandy loam with veins of grey (7.5YR6/2) clay. pH 7.06 ; C : 0.65 %.

The PO_4 contents of 0–17 cm, 17–48 cm and 48–60 cm are 0.060 %, 0.050 % and 0.032 % respectively, and the K contents 0.042 %, 0.053 % and 0.062 % respectively.

Although the amounts of phosphate and potassium released with 25 % HCl do not give exact information on the availability of the phosphate and potassium compounds (see also v. DILLEWIJN, 1952), it is nevertheless always assumed that soils having a PO_4 content lower than 0.035 % are deficient in phosphate. No limits are specified for the K content, but according to MARR (1912) the mean K content of the sugar-cane soils in Java is 0.060 %. Since all Tasikmadoe soils have a higher PO_4 content than 0.035 %, the phosphate reserve ought to be regarded as sufficient. The K contents, however, are all below the average, and the Waroe soil in particular has a very low content.

It may be taken for granted from the preliminary investigation that the potash supply of the sugar cane is entirely inadequate, although this was already deducible from the occurence of deficiency symptoms.

In order to obtain a better basis for giving fairly sound advice on fertilization, it was decided to carry out leaf analyses of the cane on three experimental fields. Although for various reasons the lay-out of the experimental fields had to be kept as simple as possible, so that not all results are equally reliable, they were nevertheless found to provide some interesting viewpoints of general tendency.

The soils selected for these tests were the Kebak soil (nitrogen experimental field), the Popongan and Waroe soil (potash experimental fields). The data relating to these soils are again tabulated in Table 2.

Table 2 Soil composition of the experimental fields.

Soil	Horizon cm	Physical state	pH	C %	K in % (25 % HCl)	PO_4 in % (25 % HCl)
Kebak .... *(Tuffmargalite)*	0–20 20–45 45–70	rather poor poor poor	6.60 6.81 7.18	1.75 1.19 0.37	0.034 0.053 0.062	0.071 0.072 0.103
Popongan ...... *(eddish-brown Latosol)*	0–40 40–70	good good	5.47 6.16	0.69 0.09	0.049 0.066	0.079 0.095
Waroe .... *(Solonetz ?)*	0–27 27–45	rather poor poor	8.42 8.43	1.15 1.19	0.037 0.037	0.060 0.056

Considering the K and PO_4 content, the Kebak and Popongan soils are similar, although they differ in physical condition, pH and C content, and the PO_4 content is also lower than in the two soils mentioned above. The C content (N content) is intermediate and the pH very high. If nitrogen is available to the plant to the same extent in all three soils, the Kebak soil will require least followed by the Waroe soil, while the Popongan soil must be very difficient in nitrogen. It will be found that, in many cases, these differences in fertility are not reflected in the composition of the leaf.

Experimental

The field experiments were designed as block experiments. There were three replications of the N fertilization experiments, whether or not combined with phosphate and potash dressings. The blocks had an area of 0.05 hectares (50 furrows). The entire experimental field covered an area of 2.4 hectares. In the potash fertilization experiments the cane received a basic dressing of phosphate and nitrogen, in accordance with normal practice. The number of replications was 6. In this case the blocks had an area of 0.038 hectares (38 furrows); the entire experimental field was 1.4 hectares. The sites and replications were randomized. For the fertilization scheme reference is made to Table 3.

The fertiliser was applied locally, as is usual in practice, and the soil was also moulded up in the normal way. Nitrogen was applied in the form of ammonium sulphate, phosphate as triple superphosphate, and potassium as muriate of potash.

After the cane had reached the age of about 13 months, the top leaves were removed from a number of plants in each block. These were dried at 105° C and ground; the various ground samples from a single site were carefully mixed together. The N, PO_4, K, Mg and Ca contents were determined of the resultant samples. The averages (i.e. of 3 and 6 determinations) are shown in Table 3.

For the method of analysis reference is made to Go Ban Hong (1957). The factory determined the weight of the cane, the rendement, and sugar yield.

The cane clone employed was P.O.J. 3061.

Only those results are given in Table 3 which showed fairly reliable differences with respect to the rendement.

Table 3 Results of fertilizer experiments Tasikmadoe 1956/1957.

Soil	Object	Fertilization kg/ha			Content of elements in top leaves (m.e./100 g dry matter)					Cane yield tons/ha	Rendement %	Sugar yield tons/ha
		z.a.[1]	d.s.[1]	k.z. 50[1]	N	PO_4	K	Mg	Ca			
Kebak . . . *(Tuffmargalite)*	1 a	500	–	–	52.9	8.5	42.4	12.4	12.0	93.0	12.91 ± 0.05	12.0
	b	600	–	–	45.7	8.5	44.2	10.0	8.0	93.8	13.19 ± 0.05	12.4
	c	800	–	–	54.3	7.2	45.0	11.6	9.4	88.6	13.29 ± 0.04	11.8
	2 a	500	150	–	50.0	9.3	41.9	13.1	11.5	109.6	12.96 ± 0.06	14.2
	b	600	150	–	51.4	8.9	45.0	13.1	11.0	119.3	13.38 ± 0.06	16.0
	c	800	150	–	59.3	10.7	48.1	12.3	11.0	121.0	13.09 ± 0.06	15.8
	3 a	500	–	300	47.9	8.0	46.0	11.6	11.0	93.8	13.04 ± 0.06	12.3
	b	600	–	300	56.4	10.7	50.0	10.7	9.5	101.8	13.14 ± 0.04	13.4
	c	800	–	300	57.1	9.3	50.2	11.6	12.0	109.6	13.02 ± 0.06	14.3
	4 a	500	150	300	48.6	9.7	50.0	10.0	11.0	118.4	12.98 ± 0.07	15.4
	b	600	150	300	48.0	10.2	50.4	10.7	11.0	115.8	13.44 ± 0.05	15.6
	c	800	150	300	45.7	8.4	44.0	9.0	9.0	128.1	13.17 ± 0.06	16.9
Popongan . *(Reddish-brown Latosol)*	5 a	700	150	–	34.3	10.7	57.3	11.6	8.5	95.3	12.83 ± 0.04	12.2
	b	700	150	400	37.1	10.7	64.2	10.7	8.5	110.6	12.98 ± 0.05	14.4
	c	700	150	700	45.0	11.4	64.4	10.0	7.0	107.2	13.16 ± 0.04	14.1
Waroe . . . *(Solonetz?)*	6 a	700	150	–	56.4	13.1	33.7	18.0	19.0	125.0	12.21 ± 0.04	15.3
	b	700	150	400	58.6	13.1	38.4	17.2	15.5	129.1	12.54 ± 0.05	16.2
	c	700	150	700	60.0	12.6	43.0	16.4	15.0	124.1	12.65 ± 0.05	15.2

[1]) z.a. = sulphate of ammonia; d.s. = triple superphosphate; k.z. 50 = muriate of potash (50 % K_2O).

Results

As Table 3 shows, the cane may be divided into four groups when considering the K content. The Waroe cane has a very low content, the Kebak cane from sites which received no K dressing shows a fairly low content, while the cane from the blocks dressed with potash has a reasonable high content; finally the Popongan cane shows a high K content. These results are in fairly close agreement with the K contents of the soils when it is remembered that the Popongan soil has a good structure and hence a considerable volume which can be penetrated by roots. Such a correlation cannot be found when one compares the PO_4 content of cane and soil. The Waroe cane has a high PO_4

content. The high content in the Waroe cane is possibly due to the large Mg uptake, since magnesium appears to increase the availability of phosphate (see DRUZHININ, 1936 ; ASKEW, 1942).

As was expected, the N content of the Popongan cane is low ; the N content of the Waroe cane is high and that of the Kebak cane intermediate. Apparently there is a considerable natural enrichment of the Waroe soil with nitrogen ; this is understandable since the conditions are present in this soil for an appreciable nitrogen fixation (sufficient calcium and phosphate : cf. the high contents in the cane). In the Popongan too little calcium (cf. the low content in the cane) and too little organic material is present for a sufficiently intensive nitrogen fixation.

The effect of the dressings on the rendement is fairly clear. In the Kebak trials a higher nitrogen dressing is sometimes found to result in increased rendement (compare, for instance, object 1c with 1a ; 4c with 4a). A heavy nitrogen dressing reduces the rendement (compare object 2b with object 2c ; object 4b with object 4c), a phenomenon which has already been observed on several occasions (e.g. GEERTS, 1920 ; VAN STRATEN VAN NES, 1931 ; KONINGSBERGER, 1931 ; v. DILLEWIJN and LEVERT, 1933 ; YUEN and BORDEN, 1940). But it is particularly a phosphate dressing that has a marked effect on the rendement (compare object 2b with object 1b ; object 4b with object 3b). Potash dressing appears to have little effect on this soil. The best rendements were obtained with a nitrogen dressing of 600 kg of sulphate of ammonia per hectare combined with 150 kg of triple superphosphate per hectare (see objects 2 b and 4b). The highest cane and sugar yield is obtained, however, with the heaviest dressing (object 4c). In this case the highest cane yield does not coincide with the highest rendement.

In the Popongan trial the potash dressing was found to have a marked effect on the rendement, although the potash content of the leaf was already high without fertiliser. In general the rendement is lower than that of the Kebak cane, probably due to the low nitrogen content of the leaf. Nor is the yield high, which likewise indicates that the N dressing given was low and that the natural nitrogen enrichment of the soil is insufficient.

The marked effect of the potash dressing on the rendement can also be observed in the case of the Waroe soil (see also DEMANDT, 1933; BORDEN, 1937, 1940, 1941). The rendements are low, this being no doubt connected with the low K content and high N content in the leaf. The high N content indicates a rich nitrogen nutrition, and the cane yields are high as a result.

DISCUSSION

The above results show that the rendement-problem is a question of interaction between the nutrient elements nitrogen, phosphorus and potassium. Since the K and PO_4 levels in the leaf also appear to be connected with the Ca and Mg levels in the leaf (cf. the composition of the Waroe cane), the relationship will be a fairly complex one.

Borden, (1937, 1940) has already pointed out the interaction that exists between nitrogen and potassium. BEACHAMP and LAZO (1938) showed that the $\frac{K_2O}{N + P_2O_5}$ ratio in the alcoholextract of sugar cane leaves is a better index of the performance of the cane than the potash content alone.

Others still attach great importance to the absolute contents of the various elements in the leaf (EVANS, 1955). The effect of the ratios of one element to another on the rendement have not hitherto been considered.

In the following discussion we shall therefore emphasis the connection between the ratios of the concentrations of the major elements and the rendement. It is quite conceivable, of course, that other elements have an effect (see above), but the necessary data on this were not available in the present investigation.

To bring some order in the discussion, we shall start from the following reasonable *assumptions* :

1) If one of the elements N, P and K is present in the leaf in sufficient quantities, the rendement-level will be determined in particular by the ratio of the concentrations of he other two elements ; 2) If two of the three elements are present in the leaf in sufficient quantities, the yield will be determined by the concentration of the third element. The ratios of the concentration of the third element to the concentration of the other two elemens will also show a relationship to the yield ; 3) It may be expected a priori that among the various ratios a value (optimum value) will occur at which the rendement is highest.

The various concentration ratios in the cane-leaf of the three trial fields are computed in Table 4. The following observations may be made with reference to this table.

Since the N content in the Waroe cane and the Kebak cane of sites 1 and 2 is sufficiently high, there must be a correlation between the rendement and the K/PO_4 ratio. Broadly speaking this proves to be true, although there are insufficient observations to enable us to indicate with certainty the optimum value in this ratio (see Fig. 1). Apparently, however, it is in the range 5.5 to 6.5.

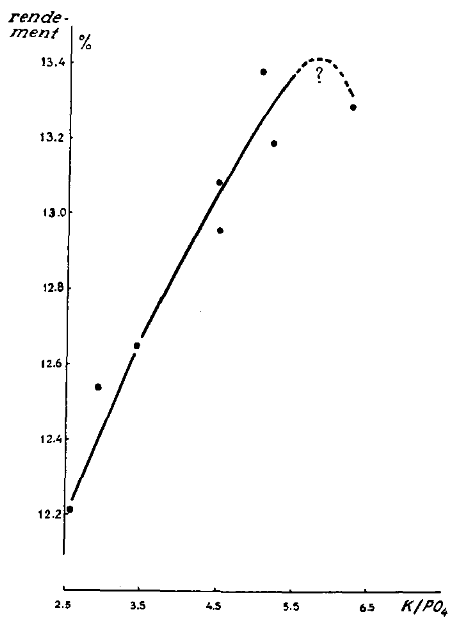

FIG. 1 RELATIONSHIP BETWEEN RENDEMENT AND LEAF K/PO_4-RATIO.

Table 4 Rendement and ratio of concentrations of elements in the leaf.

Object	Rendement	$K/PO_4 + N$	K/PO_4	K/N	PO_4/N
1 a	12.91 ± 0.05	0.691	5.00	0.801	0.160
b	13.19 ± 0.05	0.816	5.20	0.965	0.186
c	13.29 ± 0.04	0.732	6.25	0.829	0.132
2 a	12.96 ± 0.06	0.707	4.50	0.838	0.186
b	13.38 ± 0.06	0.746	5.06	0.875	0.173
c	13.09 ± 0.06	0.687	4.50	0.811	0.180
3 a	13.04 ± 0.06	0.828	5.75	0.960	0.167
b	13.14 ± 0.04	0.745	4.67	0.886	0.190
c	13.02 ± 0.06	0.755	5.37	0.877	0.163
4 a	12.98 ± 0.07	0.858	5.15	1.03	0.200
b	13.44 ± 0.05	0.866	4.94	1.05	0.213
c	13.17 ± 0.06	0.813	5.24	0.963	0.184
5 a	12.83 ± 0.04	1.27	5.35	1.67	0.312
b	12.98 ± 0.05	1.34	6.00	1.73	0.288
c	13.16 ± 0.04	1.14	5.65	1.21	0.253
6 a	12.21 ± 0.04	0.488	2.57	0.598	0.232
b	12.54 ± 0.05	0.536	2.93	0.658	0.223
c	12.65 ± 0.05	0.592	3.41	0.717	0.210

The Kebak cane of objects 3 and 4 and the Popongan has a just sufficient to a sufficiently high potash content. In this case it should be possible to observe a correlation between the rendement and the PO_4/N ratio, and this expectation is, in fact, adequately realised, as is clearly shown by Figure 2.

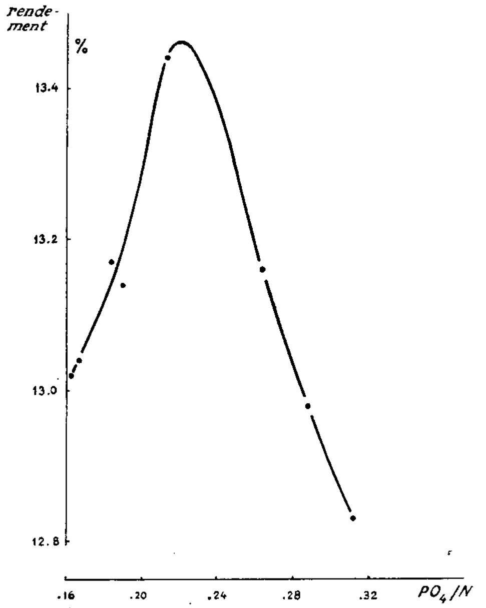

Fig. 2 Relationship between rendement and leaf PO_4/N-ratio.

The highest rendement is produced when the PO_4/N ratio is about 0.215. Hence the Popongan cane has too high a PO_4/N ratio.

The Waroe cane has a sufficiently high N and PO_4 content, so that there will be a cocrrelation between the rendement and the K content, the $K/PO_4 + N$, K/PO_4, and K/N ratios. These correlations were found to exist; an optimum value is not reached because the K contents remain at too low a level.

With the aid of these data it is now possible to give provisional advice on fertilization. No definitive advice can be given, however, until new fertiliser trials are carried out of which it will now be possible to indicate the exact plan.

In the case of the Kebak soil, emphasis should be laid on the N and PO_4 dressing. As regards yield, the optimum fertilization will be 600 kg ammonium sulphate and 150 kg triple superphosphate, but should it be desired to increase the cane yield a heavier N dressing will have to be applied; in this case, however, the PO_4 and K dressings should be increased at the same time, as otherwise the rendement will decline. A useful trial field would seem to be one in which the N and K dressings are fixed at 800 kg ammonium sulphate and 400 kg muriate of potash per hectare respectively, whereas the PO_4 dressing is varied from 100 to 400 kg triple superphosphate per hectare.

It is open to question, however, whether such heavy dressings are justified from an economic point of view. The high fertiliser requirements of the Kebak soil are undoubtedly due to the poor physical condition. It might therefore rightly be doubted whether it would not be more advisable to make deeper and wider furrows (thereby increasing the volume of soil available to the roots) than to apply heavy dressings of fertiliser. The course adopted will depend on the prices of sugar and fertiliser as well as on wages.

From the pedological standpoint more intensive cultivation of the soil would be more correct, but in our view a cost calculation will undoubtedly show that under present-day conditions fertilization would be cheaper. But however this may be, the Kebak soil is a difficult one to cultivate, both from the point of view of agronomy and agricultural chemistry.

Conditions are somewhat less complex in the case of the Popongan soil, which is not surprising when considering the good physical condition of the soil. The potash supply of the cane is quite adequate, so that a moderate K dressing, e.g. 200 kg muriate of potash, is sufficient. The PO_4/N ratio in the leaf is too high, so that either a heavier N dressing or a lighter PO_4 dressing should be applied, or both. Since the cane yield is on the low side, a higher N dressing is possibly to be preferred. In order to arrive at a definite decision, an N fertilization trial will be necessary. The PO_4 dressing may fixed at 100 kg triple superphosphate per hectare, while the N dressing should be varied from 500 to 800 kg ammonium sulphate per hectare.

It can be stated with more or less certainty that a small calcium dressing (e.g. pH not exceeding 6.5) would give very important results on this soil (cf. Go Ban Hong and v. Schuylenborgh, to be published), since calcium dressings applied to latosols result in a better N fixation and increased availibility of phosphates. For this reason it will probably be possible to reduce to a minimum the phosphate dressing, while the N dressing need not exceed 400 kg ammonium sulphate per hectare (a good N fixation can enrich the soil with 100 kg N = 500 kg ammonium sulphate per hectare: Baars, 1950).

It is evident that the definitive trial field on the Waroe soil should be mainly a potash trial field. The high N and PO_4 contents in the leaf indicate that the soil contains a sufficient amount of nitrogen and phosphate compounds which are available to the plant. The N and PO_4 dressings should therefore be drastically reduced, and the money saved can be spent on the K dressing. This will result higher $K/PO_4 + N$ (as well as K/PO_4 and K/N) ratios in the leaf and higher rendements. K fertilization trials with dressings varying from 600–800 kg muriate of potash per hectare, combined with N dressings of from 0 to 400 kg ammonium sulphate per hectare and PO_4 dressings of from 0 to 150 kg triple superphosphate per hectare, will settle the problem as to what fertilization is desirable for this soil.

As in the case of the Kebak soil, it might also be queried in this case whether more intensive tillage of the soil and better drainage would not be a more effective means of increasing production. But even if such measures would be adopted, the soil would still continue to need heavy potash dressings.

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