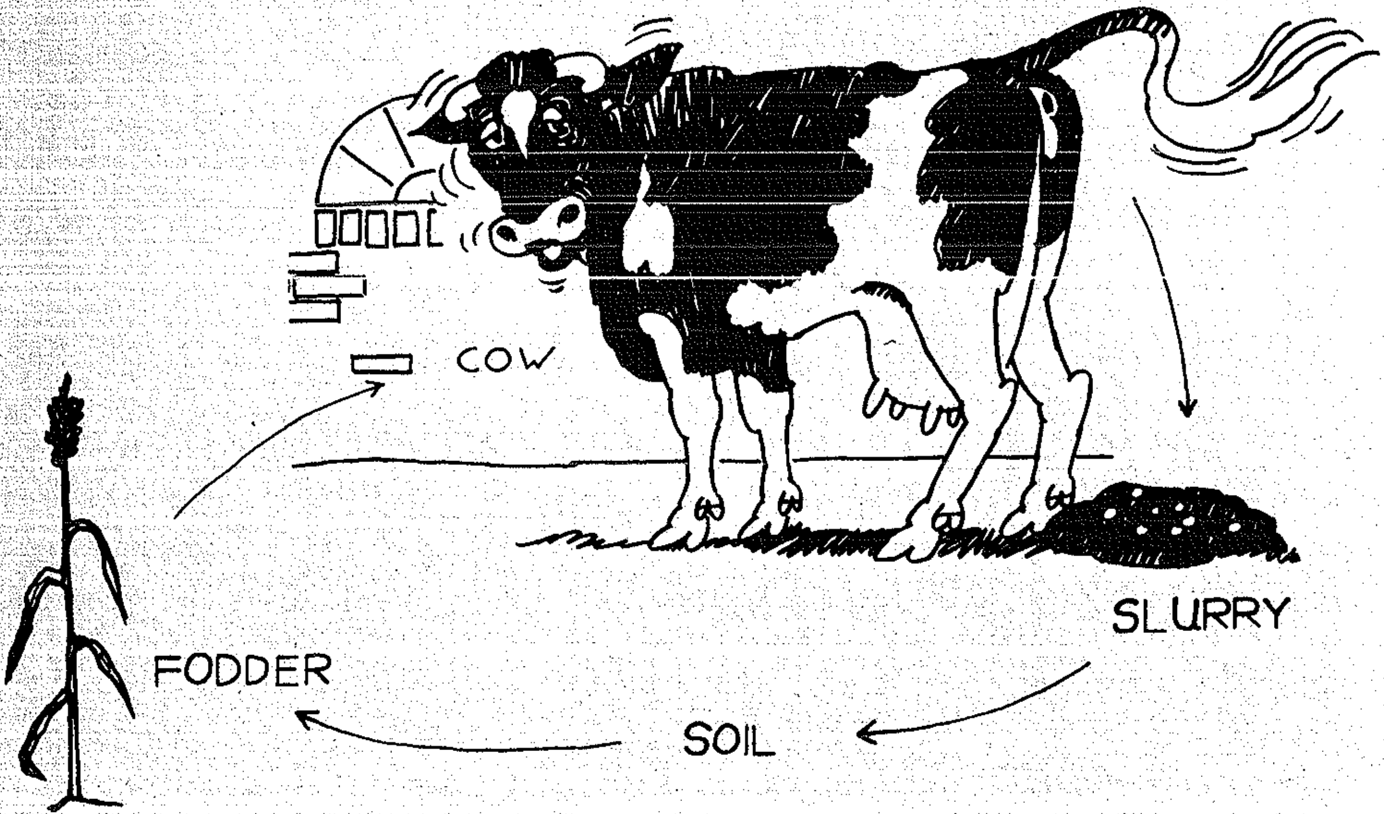
TRAINING PROJECT IN PEDOLOGY

KILIFI - KENYA



COWDUNG SLURRY AS ORGANIC MANURE FOR FODDER CROPS IN KILIFI, COAST PROVINCE KENYA

I.E. VAN DER NOLL
B.H. JANSSEN

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Contents:

Preface

This is a Preliminary Report of the Training Project in Pedology (T.P.I.P.) at Kilifi (Kenya), of the Section in Tropical Soil Science of the Department of Soil Science and Geology of the Agricultural University at Wageningen (the Netherlands).

The Training Project in Pedology was started in 1972 in the Kisii area. In 1979 the project was transfered to the Kilifi area at Kenya's Coast, and Project activities started in September. As in Kisii, this project had as its major aim the production of a mapsheet (Kilifi) on scale 1:100,000 in the frame of the Soil Map of Kenya in cooperation with the Kenya Soil Survey (Ministery of Agriculture). There are also links with the faculty of Agriculture of the University of Nairobi. Activities were terminated in November 1982.

The project was meant for training of postgraduate students of the Agricultural University at Wageningen and for furnishing research opportunities of the staff. The activities of students and staff are directed to obtain a better knowledge of the soils, and the agricultural conditions of the project area to provide a basis for further agricultural development of the area.

The project at Kilifi was conducted by:

Dr.ir. T. de Meester (Principal)
Teaching and research

Ing. H.W. Boxem (Manager)
Management and teaching

Visiting specialists from the Agricultural University at Wageningen helped to resolve special problems.
This publication reports on a post graduate study carried out by Miss Ilona E. van der Noll, postgraduate student of the Agricultural University. Fieldwork took place between April and September 1982. With reference to the Introduction it should be emphasised that we are especially grateful for the help and cooperation received from Mr.Damase Rutagengwa of the Veterinary Department, Mr. H. van Slooten of the Dairy Development Scheme, and Mr. Mwango Rjab, farmer, all at or near Kilifi.

We hope to return with this report a small part of the great debt we owe Kenya in general and to many Kenyans in particular for their valuable contributions to the project.

J. Bennema (Supervisor of the project,
Professor in Tropical Soil Science)

Summary

Cow dung slurry was compared with N and P fertilizers in its effect on growth of Napier grass and fodder sorghum, on a coastal sand soil near Kilifi, Kenya. Crop growth varied largely, what for a main part was caused by an irregular soil fertility pattern.

There was no response to P fertilizers, because soil P was at an adequate level, probably as an result of former slurry applications.

Soil N was low and N proved severely yield limiting. This was apparent from the response to N fertilizers, and from the very low N concentrations in the crops. The dung produced by the cows on the farm likewise was poor in N.

The effect of cow dung slurry on yield could be interpreted as a N fertilizing effect. Compared to CAN-N, slurry N had a effectiveness of 60-80%.

Slurry N likely consisted for a major part of inorganic N, while its organic N was rapidly mineralized. Therefore this slurry cannot be considered as a slow-release N fertilizer. As a consequence it should be applied in relatively small quantities after each cutting. It probably has an important residual effect as P fertilizer.

Key words: cow dung slurry fodder sorghum Kenya coastal sands Napier grass nutrient concentration soil fertility.

1. Introduction, aim of the study.

This report summarizes the results of a study that was a joint effort of two projects:

1. Training Project in Pedology, Kilifi.
   This project started in September 1979 and terminated, as far as its field work concerned, at the end of 1982. Its aim was to train post-graduate students in soil science and related subjects. The program included soil, vegetation and landuse surveys, and several other studies necessary in support of the landevaluation, being the eventual target of the project. One of these studies was on soil fertility, designed to identify yield limiting nutrients, to arrive at fertilizer recommendations, and to appraise locally available organic manures.
2. Dairy Development Scheme.
   This project is a part of the Dutch government aid programme. Its administration and research centres are at Nairobi and Naivasha, respectively. Demonstration and extension activities are spread over six districts, one of them being Kilifi district (since 1980). These activities are directed towards introduction of a grazing system, including the growing of fodder crops and the housing of cows in open sheds with a concrete floor and manger. The cows are fed with the fodder crops, and produce dung, which on its turn can be utilized as a manure for the crops.

It was the purpose of this study to assess the manuring value of the slurry that is obtained when dung, urine and fodder rests are swept with the cleaning water into a mixed manure pit. A number of three trials was carried out by the first author, as a part of her major in Soil Fertility at the Agricultural University of Wageningen (van der Noll, 1983). The field work was supervised by H. van Slooten (Dairy project), H.W. Boxem and T. de Meester (Pedology project), while the second author guided the study on behalf of the Department of Soil Science and Plant Nutrition of the Agricultural University of Wageningen.

2. Site description.

The study was carried out at the farm of Mr. Mwango Rajab in 1982. The location is along the main road Kilifi-Malindi, about 5 kilometres north of Kilifi.

The soil is a well drained very deep red, friable to very friable, sandy loam to sandy clay loam, underlying 15 cm brown loamy sand; it has been developed on coastal sands (Floor et al., 1980). Texture data are presented in Table 1.

Table 1. Particle-size distribution (%) of samples of the soil horizons.

Depth, cm	< 2	2-50	> 50 µm	Textural class
0 - 14	9.3	6.2	84.5	loamy sand
14 - 55	14.0	5.0	81.0	sandy loam
55 - 110+	22.0	3.0	75.0	sandy clay loam

The trials were laid down in already existing grass fields, which had received cow dung now and then in the past. This has undoubtedly contributed to the rather high levels and strong variation in soil P (Table 2). Former studies have shown that the coastal sand soils usually have P-Olsen less than 5 mg kg^{-1} and that no responses to P fertilizers are obtained if P-Olsen exceeds 5-7 mg kg^{-1}. (Batjes, 1982; de Bie, 1982; Winkelhorst, 1983).

Like in most coastal sand soils, the trial fields' soils had low organic C and N, and CEC, while their pH was about neutral (Table 2).

Table 2. Some chemical data of composite topsoil (0-20 cm) samples.

	Trial 1	Trial 2	Trial 3	
			West	East
pH - H_2O	7.0	7.2	6.8	7.0
pH - KCl	5.9	6.1	5.8	6.2
C, g kg^{-1}	4.4	9.2(?)	4.1	9.6
N org., g kg^{-1}	0.5	0.4	0.6	1.0
P-Olsen, mg kg^{-1}	9	10	16	36
P-total, mg kg^{-1}	172	186	185	345
*CEC, mmol(+) kg^{-1}	38	33	99(?)	37
exch. K, mmol kg^{-1}	5	4	3	3
exch. Ca, ½ mmol kg^{-1}	26	21	33	25
exch. Mg, ½ mmol kg^{-1}	7	6	25	10

* NH_4 acetate method at pH 7.0.

Around Kilifi there is a bimodal rainfall distribution with an average year total of 945 mm (Smaling, 1980). The long rains are from April to July and the short rains, much weaker, fall during October and November. During the trials (April-August 1982) rainfall was exceptionally high (Table 3).

Average annual evaporation is about 2000 mm.

Table 3. Rainfall (mm), 50 yr average and 1982 data. From Smaling (1980), van der Noll (1983).

	April	May	June	July	August
Average	122	268	117	78	56
1982	434	497	134	154	15 (till 15th)

3. Design, materials and methods.

In three trials cow dung slurry was compared to N and P fertilizers. Table 4 shows the dry matter of the slurry was low in all analysed nutrients except K as compared to the Dutch data. Expecially N was low. Compared to the boma (corral) manure of the Kisii area (Kenya) the slurry was rather rich. The boma manure is partly mixed with soil, which dilutes the nutrients.

Table 4. Dry matter content (kg m^{-3}) of cow dung slurry and nutrient concentration (g kg^{-1}) of its dry matter.
Slurry: mixture of 400 kg fresh cow dung + 600 kg cleaning water with fodder residues. Lower part: nutrient concentration in slurry (kg m^{-3}).

	DM	N	P	K	Ca	Mg
Trial 1	53	22.1	7.2	75	9.1	5.8
Trial 2	54	20.2	6.3	84	7.8	4.6
Trial 3	82	13.6	6.6	35	13.1	4.2
mean	63	18.6	6.7	65	10.0	4.9
boma manure[1)]		10.8	7.5	17	9.1	2.3
cow dung slurry[2)]	95	46.3	9.1	44	15.0	6.3
Trial 1		1.17	0.38	3.98	0.48	0.31
Trial 2		1.09	0.34	4.54	0.42	0.25
Trial 3		1.15	0.54	2.94	1.07	0.34
mean		1.14	0.42	3.82	0.66	0.30

1) Oenema, 1980; Kisii, Kenya.

2) Pelser, 1980; average values in the Netherlands.

Trial 1. In a 4^2 factorial N was applied as calcium ammonium nitrate (CAN; 26% N) at rates of 0, 20, 40 and 80 kg ha^{-1}, and P as triplesuperphosphate (TSP; 46% P_2O_5 = 20% P) at rates of 0, 15, 30 and 45 kg ha^{-1} P. The trial field was subdivided into four subblocs, each consisting of six plots. Two plots received slurry at rates corresponding with 55 and 110 kg ha^{-1} N, respectively. The other four plots of a subbloc formed each time a 2^2 NP factorial. The test crop was Napier grass or elephant grass (Pennisetum purpereum Schum). Each plot consisted of 5 rows of 4 m length, about 70 cm apart, so gross plot size was 14 m^2. The distance between plants in a row was 70 cm. At harvest outer plants were discarded, leaving 12 net plants per plot. Variations in these numbers did occur, as plant spacing was irregular here and there.

Slurry and fertilizers were applied in trenches around each plant and covered with soil, after cutting the standing crop. The trial started on 27th of April, 1982, first cutting was on 24th of June and second cutting on 2nd of September, i.e. after 58 and 70 days, respectively. At harvest plants were 1.0 - 1.5 m high. They were weighed in the field and samples were taken for determination of dry matter and nutrient content. After the first cutting application of fertilizers or slurry was not repeated.

Trial 2. This trial was executed in the same way and time and with the same crop as Trial 1, but this time fertilizers and slurry were applied after the first cutting. The design was a 3^2 factorial with N rates of 0, 20 and 40 kg ha^{-1} and P rates of 0, 15 and 30 kg ha^{-1}. Three plots received cow dung slurry at a rate of 50 kg ha^{-1} N. The 12 plots were randomized within one bloc. During the first growing period all plots had received N and P at rates of 20 and 15 kg ha^{-1}, respectively.

This trial was devised to imitate the practice of the farmers, who apply the slurry not at the start of the growing season, but some weeks later. Sometimes they apply commercial fertilizers at the beginning of growth period.

Trial 3. The design was exactly the same as for Trial 1, but now the crop was Columbus grass or fodder sorghum (Sorghum x Almum Parodi). Each plot consisted of 6 rows of 4 m, 60 cm apart; net plot size was 7.2 m^2.

After the field had been cleared and tilled, sorghum was sown. At the same day, 22th of May 1982, fertilizers and slurry were applied in trenches along the plant rows and covered with soil. Empty places were resown on 11th of June. Harvest was on 3rd of August, i.e. 73 (53) days after sowing. Plants were weighed in the field and sampled for further analysis.

4. Results.

4.1 Dry matter yields.

Trial 1. There was a large variation in crop performance. Variability in soil was one source of variation. A second source was the difference between plots in the ratio of original and replanted grass, of which the latter generally produced less. As plants had been weighed individually yield data could be more or less corrected by standardizing this ratio. This was not done for the second cutting, as it was unlikely that then the effect of replanting would exist any more. Dry matter production was about equal for both cuttings (Table 5). There was no response to P, which is in accordance with the fact that P-Olsen (Table 2) was above the critical value of 7 mg kg^{-1}. The response to N was more clear in the first than in the second period. The reason probably was that a large part of the applied N had been leached by rains in April and May. The effects of low and high slurry applications corresponded with those of fertilizer N levels of about 30 and more than 80 kg ha^{-1}, respectively.

Table 5. Trial 1. Napier grass. Dry matter yield (tons ha^{-1}).

Cutting	P applied kg ha^{-1}	N applied, kg ha^{-1} 10	20	40	80	mean
1	0	1.7	3.4	4.6	3.0	3.2
	15	1.9	3.0	2.4	6.0	3.3
	30	3.3	2.1	4.0	3.6	3.3
	45	2.5	3.1	3.6	3.6	3.2
	mean	2.4	2.9	3.7	4.1	3.2
2	0	3.0	2.8	4.3	3.5	3.4
	15	1.8	3.6	2.2	5.7	3.3
	30	2.6	1.8	3.4	1.9	2.4
	45	2.2	5.1	2.6	2.9	3.2
	mean	2.4	3.3	3.1	3.5	3.1
1+2	0	4.7	6.2	8.9	6.5	6.6
	15	3.7	6.6	4.6	11.7	6.7
	30	5.9	3.9	7.4	5.5	5.7
	45	4.7	8.2	6.3	6.5	6.4
	mean	4.8	6.2	6.8	7.6	6.3
	Slurry kg ha^{-1} N	Subbloc 1	2	3	4	mean
1	55	2.8	2.9	4.1	(2.6)[1)]	3.3
	110	4.0	4.5	4.9	8.2[2)]	5.4 (4.5)[2)]
2	55	2.6	2.6	3.4	(4.0)[1)]	2.9
	110	4.5	3.2	4.9	7.1[2)]	4.9 (4.2)[2)]
1+2	55	5.4	5.5	7.7	(6.6)[1)]	6.2
	110	8.5	7.7	9.8	15.3	10.3 (8.7)[2)]

1) Only half of the required amount was applied, corresponding with 28 kg ha^{-1} N. Not included in mean value.

2) This plot apparently had an exceptionally high yield; the mean in brackets is from the three other plots.

Trial 2. The first cutting yielded 4.2 tons ha^{-1} on an average, but among the plots yields varied from 2.4 to 6.4 tons ha^{-1}. The yields of the second harvest were adjusted for this variation. Also in this trial no clear response to P was found (Table 6). The response to N was irregular, but on the average substantial. Slurry application resulted in yields similar to the ones which would have been obtained with fertilizer N at a rate of 30 kg ha^{-1}.

Table 6. Trial 2. Napier grass. Dry matter yield (tons ha^{-1}). Second cutting.

P applied	N applied, kg ha^{-1}				Slurry, 50 kg ha^{-1} N		
kg ha^{-1}	0	20	40	mean			
0	2.7	5.3	5.8	4.6	plot	1	5.2
15	5.1	5.6	5.1	5.3		2	5.1
30	3.0	4.8	7.7	5.2		3	7.0
mean	3.6	5.2	6.2	5.0	mean:		5.8

Generally Trial 2 yielded better than Trial 1. This should probably partly be attributed to a difference in soil fertility, although soil analytical data (Table 2) do not support this supposition. An obvious reason for the yield difference during the second period is that fertilizers and slurry had been applied at the start of the first period in Trial 1 and at the start of the second period in Trial 2.

Trial 3. As there was a clear difference in crop growth between the western and the eastern part of the field, Table 7 presents separate data for these parts. Table 2 shows that there also was a difference in soil fertility parameters. The western part was surrounded by cashewnut trees, the eastern part by mangos. Only in the western part a - though - weak response to N was found. Again there was no response to P. When slurry was applied sorghum grew better than when fertilizers were applied, but due to the large variation this conclusion is not too firm.

Table 7. Trial 3. Foddersorghum. Dry matter yield (tons ha^{-1}).

P applied kg ha^{-1}	West N applied, kg ha^{-1} 0	40	mean	East N applied, kg ha^{-1} 20	80	mean
0	2.2	3.7	2.9	4.6	3.8	4.2
15	3.2	3.0	3.1	4.3	5.0	4.6
30	3.1	2.8	3.0	4.6	4.8	4.7
45	2.0	2.5	2.3	4.5	4.5	4.5
mean	2.6	3.0	2.8	4.5	4.5	4.5
Slurry kg N ha^{-1}	**Subbloc 1**	**2**	**mean**	**Subbloc 3**	**4**	**mean**
52	2.6	3.5	3.1	5.3	4.9	5.1
104	4.5	n.d.		4.9	4.8	4.8

4.2 Nutrient concentrations and nitrogen uptake

Napier grass. The second cutting of Napier grass generally had lower concentrations of N, P and K than the first cutting, while Ca and Mg concentrations were at about the same level for both cuttings (Table 8). This agrees with the findings of Appelman and Dirven (1962), Gomide et al. (1969), and Prospero and Peixoto (1972), who studied the course of nutrient concentrations with age of Napier grass. The average data for Napier grass of 58 and 70 days old, given in Table 8, have been estimated by interpolation of their results. The P data of Appelman and Dirven (1962), differing too much from the others, were not included in the averages. Concentrations of P, K and Ca were above, of Mg somewhat below, and of N far below average. This is in line with the results of tables 5 and 6: a response to N, but not to P application.

Table 8. Nutrient concentrations in the dry matter of the harvested crops (g kg^{-1}). Age in days since last cutting.

Crop	Trial	Cutting	Age	N	P	K	Ca	Mg
Napier grass	1	1	58	6.6	3.3	39.9	4.0	1.4
	Average from lit.[1)]			14.5	1.8	35	2.0	2.0
	1	2	70	5.7	3.0	37.8	4.0	1.5
	2	2	70	5.3	2.2	36.5	3.3	1.4
	Average from lit.[1)]			12.5	1.5	3.2	2.2	2.0
	Dirven and Appelman (1962)			6.3				
Fodder sorgum	3	West	67	11.0	2.3	20.3	2.6	2.7
		East	67	11.7	2.4	16.5	2.7	2.5

1) See text.

Except for P and Ca, there was not much difference in nutrient concentrations of the second cuttings of trials 1 and 2. The lower P concentrations in Trial 2 proved related to the higher dry matter production in this trial. In the graphs of Fig. 1 yields are the mean yields for the different fertilizer and slurry N rates, as presented in tables 5, 6 and 7. The decrease in concentration with yield was much sharper for P than for K, indicating that the supply of K by the soil was relatively larger than the supply of P. As yield increase had been brought about by N application, N concentration hardly changed with increasing yield. Moreover N concentrations already were at a minimum level.

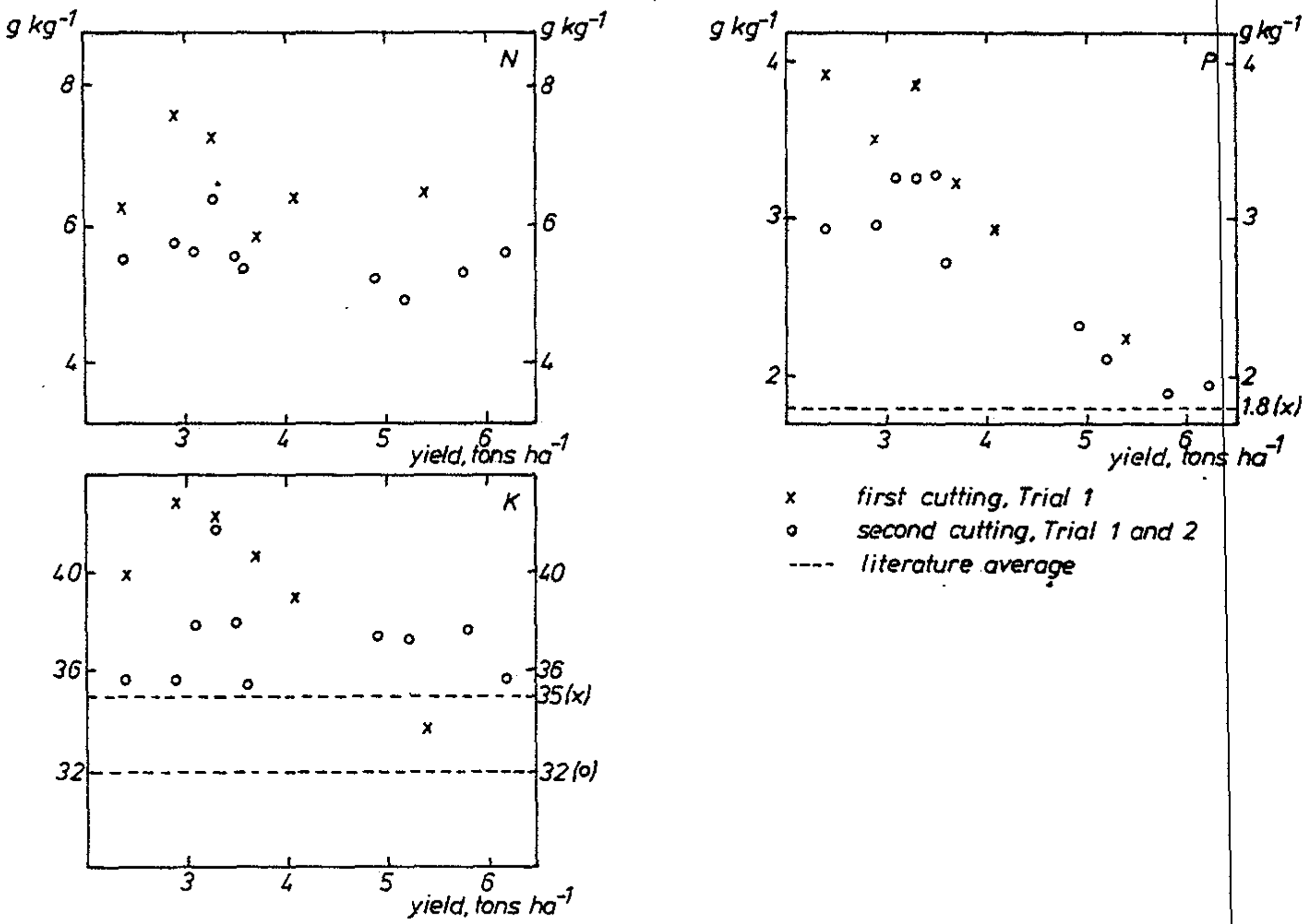

Fig. 1. Concentrations of N, P and K, as related to dry matter yield of Napier grass.

Data on nitrogen uptake and on apparent recovery of applied nitrogen are given in Table 9 and Table 10, respectively. Napier grass was able to withdraw 28 kg N form the soil in a total growth period of 126 days. This value is close to the 27-40 kg which de Bie (1982) found for maize (growth period 116 days) on a similar coastal sand soil, that contained 0.4 g kg^{-1} organic N.

Table 9. Nitrogen uptake, averaged over all P levels. N application and uptake in kg ha^{-1}.

Crop	Trial	Cutting	N applied, as CAN				as slurry	
			0	20	40	80	50–55	104–110
Napier	1	1	15.0	21.9	21.4	26.2	23.9	34.8 (29.0)[1]
grass		2	13.2	21.0	17.3	19.3	14.9	25.5 (21.9)
		1 2	28.2	42.9	38.7	45.5	38.8	60.3 (50.9)
	2		19.2	25.4	34.7		30.6	
Fodder	3W	1	33.1		28.9		23.8	54.1
sorghum	E			49.8	52.8		62.5	63.6

1) See remark 2 of Table 5.

One cutting of Napier grass could recover about 1/3 of fertilizer N applied at a rate of 20 kg ha^{-1}. At higher fertilizer rates and for slurry N recovery was much lower (Table 10). It might be concluded that it is more economic to apply small amounts of N after each cutting than larger amounts at once for a number of cuttings. There were no indications that slurry had behaved as a slow release fertizer, for its N recovery during the second period of Trial 1 was not better, relative to fertilizer N recovery, than in the first period. Apparent recovery of slurry N varied considerably; this might partly be due to bias caused by the irregular soil fertility pattern as well by varying compositions of individual slurry batches applied to different plots.

Table 5 has shown that in subbloc 4 of Trial 1, where yields were higher than in the other subblocs, a 55 kg slurry-N plot was missing and the 110 kg slurry-N plot yielded exceptionally high. By that, calculated average yields, N uptakes and N recoveries were overestimated for the treatment of 110 kg slurry-N and underestimated for the treatment of 55 kg slurry-N. This explains why apparent recovery was higher for 110 kg than for 55 kg slurry-N.

Table 10. Apparent N recovery by Napier grass in % of applied nitrogen. Applied N in kg ha^{-1}.

Trial	Cutting	N applied as CAN				as slurry
		20	40	80	50-55	104-110
1	1	35	16	14	16	18 (13)[1]
	2	39	10	8	23	11 (8)
	1+2	74	26	22	19	29 (21)
2	2	31	39		23	

Fodder sorghum had lower P, K and Ca, and higher N and Mg concentrations than Napier grass (Table 8). Fig. 2 shows the relationship between N, P, K concentrations and dry matter yield. The indicated nutrient criteria were derived for Johnson grass (Sorghum halepense) at boot stage (Martin and Matocha, 1973, using data of Spooner et al., 1971); this crop is closely related to fodder sorghum. According to these standards N was deficient or critical, and P and K were about adequate. The higher yields in Fig. 2 were from the eastern part of the field, which was higher in soil organic N and in P than the western part. Exchangeable K, however, was equal in both field halves. This might explain why K concentration in fodder sorghum decreased with yield, whereas N and P concentrations were not clearly related to yield.

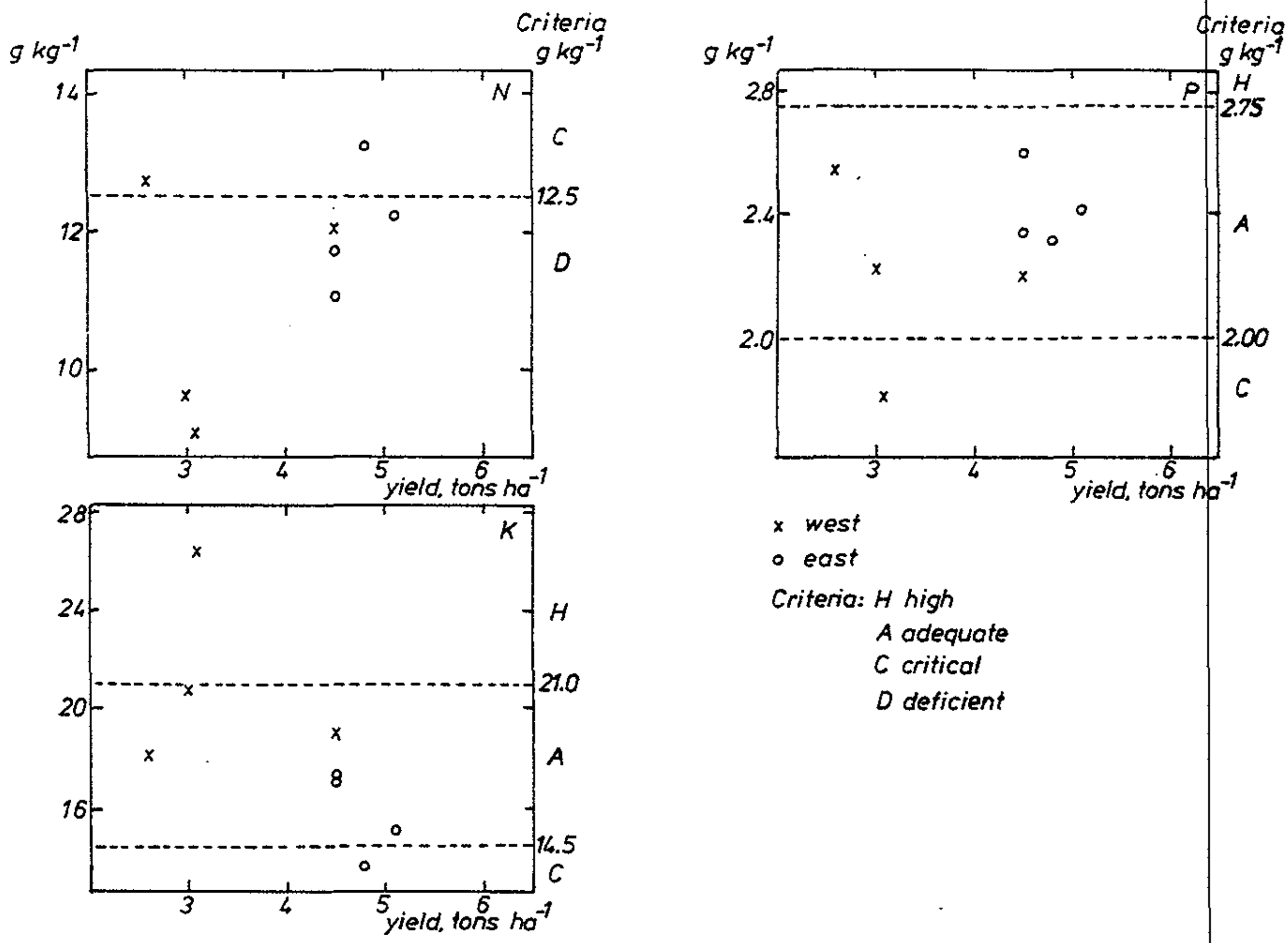

Fig. 2. Concentrations of N, P and K, as related to dry matter yield of fodder sorghum.

Uptake of N by fodder sorghum was higher in the eastern than in the western part of the field. Application of N had no clear effect on N uptake (Table 9). Apparent N recovery was not calculated as data were too irregular.

5. Evaluation of cow dung slurry.

The effectivenes of cow dung slurry was estimated by means of the relationship between N application and dry matter yield, N application and N uptake, and N uptake and yield. Fig. 3 shows these relationships for the first and the sum of both cuttings in Trial 1. The effectivenes was calculated (Table 11) as 100 * the ratio of the application rates of fertilizer and slurry N, which gave the same yields or uptake. For instance: during the first period yield at an application of 55 kg of slurry N equaled that of 30 kg fertilizer N (Fig. 3, quadrant IV); so the effectiveness of slurry N was 100 * 30/55 = 55%.

Table 11. Effectiveness of slurry N (%) as compared to fertilizer N (= 100%).

Slurry N, kg ha^{-1}		50-55		110	
Comparison by		yield	N uptake	yield	N uptake
Trial 1	Cutting 1	55	80	100	100[3)]
	2[1)]	36	18	100	100
	1+2	38	45	100	100
Trial 2	2[2)]	68	62		

1) Slurry and fertilizer applied at the start of the first growing period.

2) Slurry and fertilizer N applied at the start of the second growing period.

3) See comments in text.

Effectiveness was lower for the sum of both cuttings than for the first cutting. This again indicates that slurry did not act as a slow-release fertilizer. Probably a considerable part of slurry N was inorganic N and present in the solution, and its organic N was rapidly mineralized.

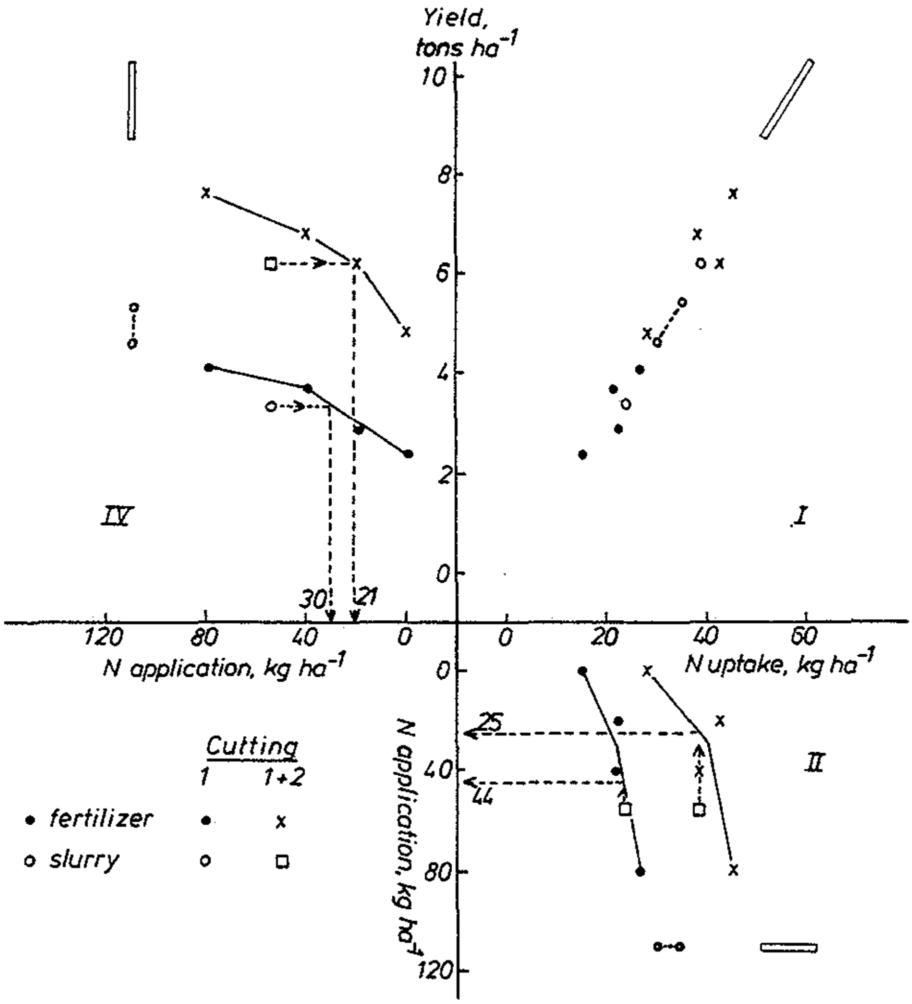

Fig. 3. Relationships between N application, N uptake and dry matter yield of Napier grass. Trial 1.

As yield and N uptake at an application of 110 kg slurry N were higher than those obtained with fertilizer N, it was not possible to calculate effectiveness. Extrapolation of the curves in Fig. 3 would lead to the conclusion that slurry N was at least as effective as fertilizer N. However, as shown in Section 4.2, yields and N uptake for the treatments of 55 and 110 kg slurry N had been under- and overestimated, respectively. The same holds for the calculated effectiveness. By and large, effectiveness might be assessed at about 80% for the first growth period of Trial 1.

The relationship between N uptake and yield (quadrant I) was the same for both fertilizer and slurry. This suggests that the effect of slurry was to be attributed to the N that slurry contained, and not to an improvement in soil physical conditions or otherwise, which could have been brought about.

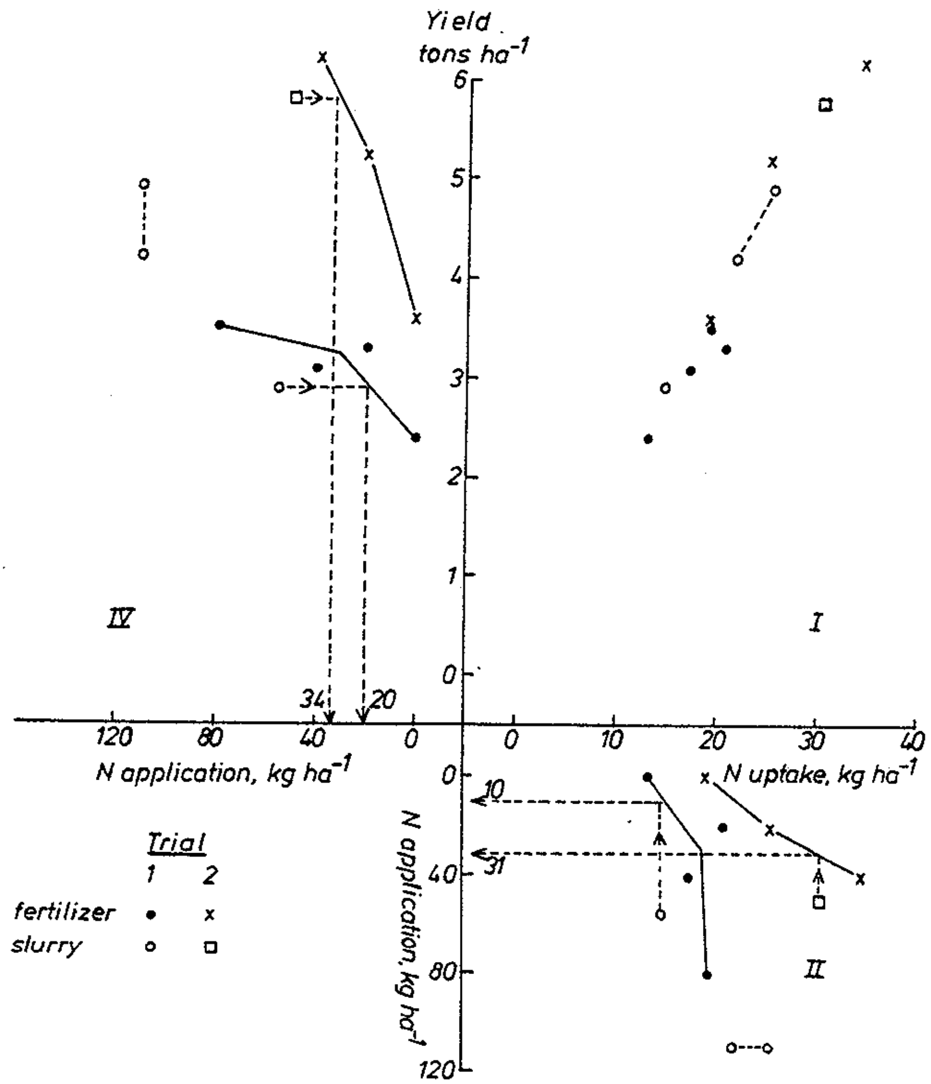

Fig. 4. Relationships between N application, N uptake and dry matter yield of Napier grass. Second cuttings of Trial 1 and Trial 2.

Because in Trial 2 N had been applied at the start of the second and in Trial 1 at the start of the first growing period, responses to N applications were sharper in Trial 2 than in Trial 1 for the second growth period. (Fig. 4). The irregular results in Trial 1 make it rather risky to estimate slurry effectiveness. Effectiveness certainly was higher in Trial 2 than in Trial 1, again demonstrating that the effect of slurry did not last longer than that of fertilizers.
The results of Trial 3 did not provide a possibility to assess slurry effectiveness.

6. Conclusions.

Notwithstanding the large variability in yields, the following conclusions can be drawn.

1. The most limiting nutrient was N. This showed up in a low soil organic N content and low N concentrations in both crops Napier grass and fodder sorghum and in cow dung.
2. Application of 80 kg CAN-N probably was not high enough to obtain maximum yields. Yet it is recommended to apply not more than 40 kg CAN-N after each cutting of Napier grass, because with higher application rates an increasing portion of applied N is not taken up by the crop.
   For the time being the same recommendation is given for fodder sorghum.
3. The soil provided sufficient P for the present dry matter productions, which likely was a result of former applications of cow dung slurry. This points to a residual P effect of the slurry.
4. The short-term effect of slurry on yield was a N fertilizing effect.
5. Slurry N effectiveness was estimated at 60-80% compared to CAN-N.
6. Slurry did not act as an slow-release fertilizer. Its residual N effect was not higher than that of CAN.

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