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PASTURE LEGUME NUTRIENTS for YELLOW EARTH SOILS

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PASTURE LEGUME NUTRIENTS for YELLOW EARTH SOILS

THE EFFECT OF POTASSIUM, ZINC, COPPER AND MOLYBDENUM ON PASTURE LEGUME GROWTH ON YELLOW EARTH SOILS IN THE DOUGLAS/DALY AREA, NT

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SUMMARY

Nutrient omission trials were conducted over four years at ten sites on yellow earths in the Douglas/Daly region of the Northern Territory. The over-riding response was to basal P and S. When these were supplied, zinc deficiency became limiting at two of the sites. Response to added zinc was associated with zinc levels less than 10 ppm in plant tops at harvest in early March. Omission of K, Cu or Mo had no effect on yield of *Stylosanthes hamata.*

These soils are suitable for the growth of legume based pastures with the addition of only P and S fertilisers at 8 sites and Zn as well at the other 2. Potassium may be required in some of these soils if there is a high removal of plant material.

INTRODUCTION

The yellow earth soils of the Douglas/Daly area of the NT referred to in this study are a group of poorly drained soils which have limited trafficability in the wet season. They tend to be partially waterlogged and boggy, have a low surface water holding capacity and may contain high levels of gravel. They are not those yellow earths which may be associated with valley floors, drainage lines or alluvial levees.

These soils were most recently classified as yellow earths by Lucas *et al* (1987). They had previously been classified as yellow earths, yellow podzolics and lateritic podzolics by Aldrick and Robinson (1972).

These soils represent a significant proportion of the soils on each property in the Douglas/Daly area, including 23.2% of the ADMA acquisition area surveyed by Lucas (1983).

Soil fertility studies in the Douglas/Daly area had been confined to the red earths which had been developed for cropping. It is expected that the yellow earths will be developed primarily for improved pastures. Little was known of the nutrient status of these soils, although responses to phosphorus and sulphur could be predicted and available potassium and zinc levels appeared low in some soils (Appendix 1).

This study was conducted to determine which nutrients other than P and S may limit productivity of legume based pastures on yellow earthy soils in the Douglas/Daly area.

MATERIALS AND METHODS

During 1982, ten sites were selected on "Kumbyechants" and the Fleming block, (now Middle Creek Station) in the Douglas/Daly area near Douglas Daly Research Farm 250 km SW of Darwin (DDRF AAR 1200 mm) in conjunction with the Land Conservation Unit of the Conservation Commission of the NT. The location of these sites is shown in Figure 1. The soils have been described and classified as yellow earths by Lucas *et al* (1987). The vegetation is described by Lucas (1983). Soil Descriptions, physical and chemical analyses are presented in Appendix 1.

Small trees were removed, large trees were killed with Tordon 50-D®, the sites were fenced and each site was cultivated to control grasses and regrowth prior to the commencement of the trial.

The plots were 4m x 5m with 1.5 m laneways. Plots were marked out and all nutrient treatments were applied for each site on the day the area was sown.

The whole of each trial site was sown with Verano (*Stylosanthes hamata)* at 12 kg pods/ha between 3-17 January 1983.

Five replications of an omission trial with 7 treatments were set up at nine of the sites and four replications at a tenth site (Site 1) where space was limiting.

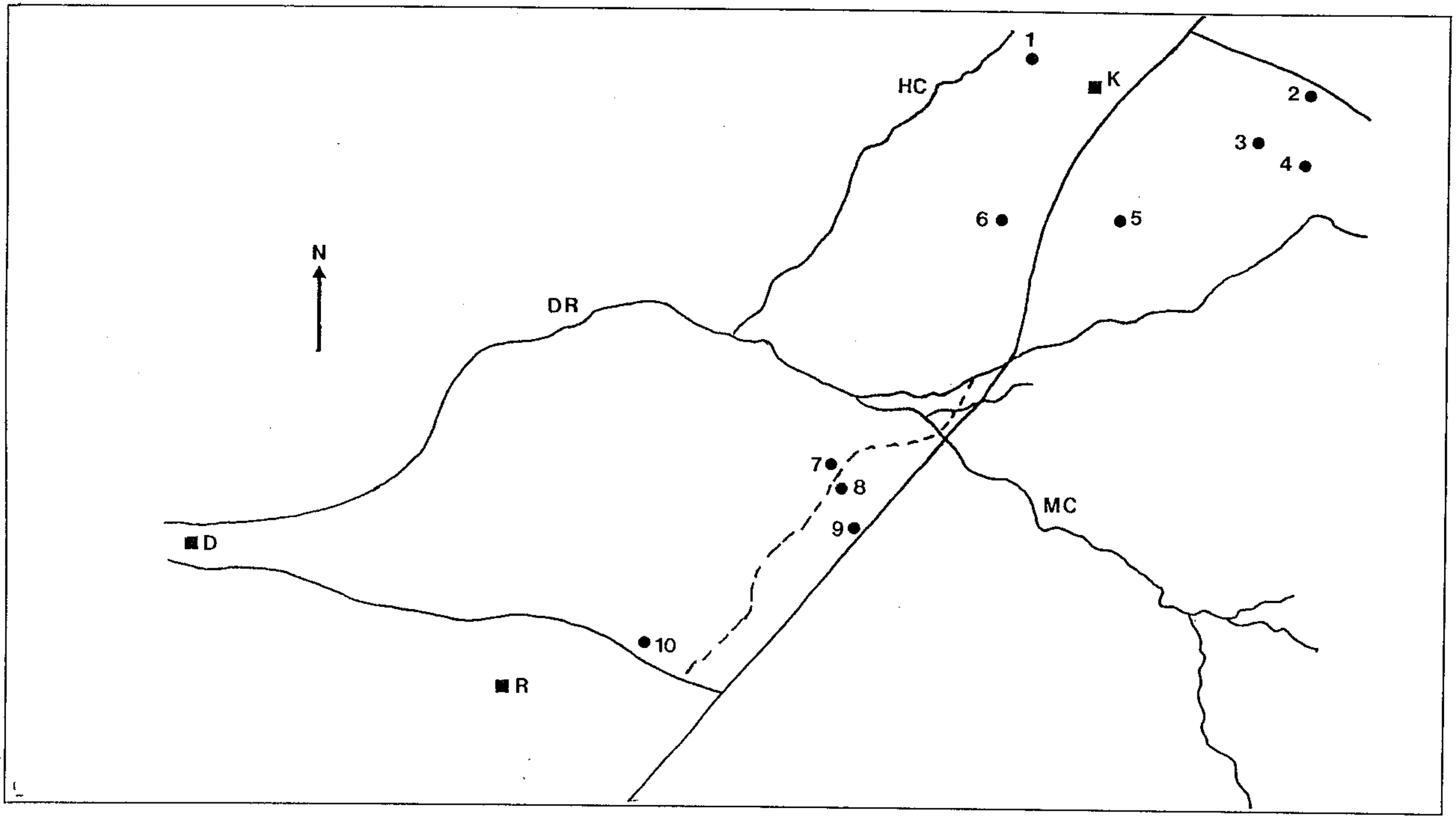

Figure 1:Location of the 10 sites in the Douglas Daly area (•1 - Sites; D = Douglas Daly Research Farm; K = Kumbyechants; R = Ruby Downs; DR - Douglas River; HC = Hayes Creek; MC = Middle Creek).

A control received P, K, S, Cu, Zn and Mo. The remaining treatments omitted either all nutrients, all except basal P and S or only K, Cu, Zn or Mo individually.

The rates and forms of the nutrients applied are presented in Table 1. The phosphorus and sulphur were spread by hand and the remaining nutrients were sprayed onto the plots in solution. A further application of basal P and S was made at the beginning of the third year of the trial.

Table 1: Rates and Forms of Nutrients Applied

Element	Rate of Element kg/ha	Form
P	30	$Ca(H_2PO_4)_2$
S	30	Na_2So_4
Zn	5	$ZnSO_4.7H_2O$
K	50	KC1
Mo	0.2	$NaMoO_4.2H_2O$
Cu	5	$CuSO_4.5H_2O$

Establishment counts in two 0.25 m^2 quadrats per plot were carried out on 21-22 February, 1983. No destructive harvesting was carried out during the first growing season, but samples were taken from selected plots on 18-20 April, 1983 for chemical analyses. In subsequent years, a 1 m^2 strip was harvested with a Jari mower on 13 March - 5 April 1984, 4-15 March 1985 and 3-6 March 1986. The samples were dried in a forced draught oven at 80°C, weighed and analysed for content of N, P, S, K, Ca, Mg, Cu and Zn. The Mo content of selected samples was also determined.

In June of each year, the whole trial was mown and the cut material removed. The plots were kept free of weeds and grass.

RESULTS

As there were no rain gauges at the sites, rainfall from Kumbyechants which is close to sites 1-6 and DDRF which is not far away are presented (Table 2). Rainfall at DDRF was below average in 1982/83 at 961 mm, above average in 1983/84 at 1420 mm, average in 1984/85 at 1175 mm and well below average in 1985/86 sat 849 mm. The corresponding totals at Kumbyechants were 1458, 1219, 1411 and 1158 mm respectively. These were all on or above the DDRF average.

While the totals at the two sites differed, the distributions of rainfall at the sites were similar.

The 1982/83 wet season extended from November to April with January and February receiving low rainfall and March-April receiving high rainfall.

Table 2: Monthly and total rainfall for Douglas Daly Research Farm and Kumbyechants for the 1982/83-1985/86 wet seasons (mm).

SEASON	SITE	MONTH										TOTAL
		A	S	O	N	D	J	F	M	A	M	
1982/83	DD	2	-	-	104	101	118	159	344	133	-	961
	KU	-	-	9	55	382	194	71	393	354	-	1458
1983/84	DD	-	-	39	242	59	345	276	460	-	-	1420
	KU	-	-	-	113	104	399	286	317	-	-	1219
1984/85	DD	-	36	-	122	180	240	276	155	167	-	1175
	KU	-	-	-	110	373	205	269	114	340	-	1411
1985/86	DD	1	1	10	135	112	300	77	98	78	37	849
	KU	-	-	-	226	167	398	117	123	77	50	1158
Average	DD	-	7	38	106	54	273	293	272	42	7	1197

In 1983/84 the wet season duration was October (DD) or November (KU) to March with high November (DD only) and March and low December (DD only) rainfall.

In 1984/85 after an opening rain in September (DD only) and none in October, the wet season extended from November to April, with most months receiving close to average rainfall except March (low) and April (high).

After light falls of rain in August, September and October (DD only), the 1985/86 wet season commenced in November and continued through to include May. The wet season was characterised by low rainfall in February and March and late rain in April and May.

ESTABLISHMENT

Establishment was good at all sites, averaging 32 plants/m^2 with no effect of treatment.

Yield

The over-riding response was a highly significant reduction in yield rating in 1983 and in legume yield to the omission of basal phosphorus and sulphur at all sites in all years, 1984-86. The magnitude of the response is illustrated in Table 3 and a summary of yield ratings and dry matter yields are presented in Appendices 2 and 3 respectively. Over the 10 sites, maximum yield was obtained from the treatment where all fertilisers were applied. Ninety percent of the maximum yield was obtained with the addition of P and S. Yield without fertiliser was 23% of the maximum.

A large P response and a smaller additive S response were found in P and S rate trials adjacent to the omission trial sites (authors, unpublished data).

The only consistent effects of nutrients on the yield ratings in 1983 were to Zn omission of Sites 8 and 9 (Appendix 2). These were only significant ($P<0.01$) at Site 9.

Table 3: Total Yield of Verano Over Three Years (1984-86) of Nil and Fertilised Plots.

Site	Verano Dry Matter (kg/ha)	
	Nil	Fertilised Plots
1	4290	18140
2	2270	17690
3	2520	14780
4	4990	19110
5	7790	20680
6	10370	21740
7	2580	17740
8	1650	14040
9	3770	21310
10	3150	16380

When the Nil plots were excluded from the analysis of variance, 3 sites showed significantly reduced yield compared with the All treatment in one or more years where zinc was omitted (Table 4).

Table 4: Significant Effects of Zinc Omission on Verano Yield (Nil plots excluded).

Site	Significance Level			
	1984	1985	1986	3 year total
3		*		
8		**	**	**
10		**		**

*$P<0.05$, **$P<0.01$

At Sites 8 and 10 the total yield from 1984 to 1986 was significantly lower with omission of Zn. Dry matter yields from the last 3 years of the trial at sites 8 and 10 are presented in Table 5.

At Site 3 in 1985 there was a significant reduction in yield with omission of Zn and a similar trend in 1986, although yield of all treatments was low in 1986 as a result of dry seasonal conditions.

Table 5: Total Dry Matter Yield of Verano Over Three Years 1984-1986 at Sites 8 and 10.

Treatment	Verano Yield (kg/ha dry matter)	
	Site 8	Site 10
Basal P & S	10183 a*	15071 ab
All	15132 b	16669 bc
All-Zn	10378 a	13180 a
All-K	15028 b	16848 bc
All-Mo	15717 b	17489 bc
All-Cu	17809 b	18904 c

* Values within the same column followed by the same letter do not differ significantly. (P<0.01)

Averaged over the 10 sites the difference of 10% between the All and Basal treatment is explained by the omission of Zn (Appendix 3).

There were no significant responses to the omission of K, Cu or Mo at any of the ten sites in any of the 4 years of the trial.

Nutrient Concentrations

Mean P concentration of the Nil treatment during the course of the trial was .07% while that of the plots receiving basal P was .09% (Table 6).

Table 6: Mean Phosphorus Concentration of Verano from Nil Plots and Plots with Phosphorus Applied, Sampled March - April Each Year.

Treatment	P%				
	1983*	1984	1985*	1986	Mean
Nil	.08	.06	.07	.07	.07
Fertilised	.10	.07	.12	.09	.09

*Fertiliser applied in 1983 and 1985

Mean plant S level in the Nil plots was .09% compared to 0.10% for plots receiving P and S (Table 7).

The P and S concentrations from fertilised plots were higher in the first and third years, the years of fertiliser application, than in the intervening years.

Mean P and S concentration for each site and year are presented in Appendix 4. The mean P and S concentrations followed a similar trend for the Nil and fertilised plots.

Table 7: Mean Sulphur Concentration of Verano from Plots Nil and with Sulphur Applied, Sampled March - April Each Year.

Treatment	S %				
	1983*	1984	1985*	1986	Mean
Nil	.09	.08	.09	.08	.09
Fertilised	.12	.09	.12	.08	.10

* Fertiliser was applied in 1983 and 1985.

Significant reduction in yield was associated with plant zinc levels 10 ppm or less (Table 8). However, the same levels were found at Site 9 but showing no apparent zinc deficiency and no difference in dry matter yield.

Table 8: Zinc Concentration in Verano Tops at Harvest, 1984-1986 (ppm).

Treatment	Year	Site									
		1	2	3	4	5	6	7	8	9	10
Nil	**1984**	26	39	27	23	34	33	35	18	17	22
	1985	34	45	35	36	25	32	32	22	25	25
	1986	26	53	31	32	23	35	36	22	28	29
Basal	**1984**	15	23	18	16	20	23	21	10	9	16
	1985	11	24	11	12	13	20	12	8	8	10
	1986	11	37	12	13	11	22	11	9	9	10
All	**1984**	14	39	51	44	35	28	47	44	34	50
	1985	27	32	29	37	24	27	33	28	30	47
	1986	41	44	46	44	30	29	41	30	36	60
All-Zn	**1984**	12	26	14	18	19	23	20	11	10	12
	1985	12	24	10	14	11	14	12	8	9	8
	1986	11	36	11	13	12	26	16	9	9	11

At the two most responsive Sites 8 and 10, the omission of zinc did not consistently affect the levels of other nutrients except for P and S at Site 8 in 1985 and 1986 and at Site 10 in 1986 where levels were higher for the All Treatment than in the Basal and -Zn treatments.

The omission of K, Cu and Mo did not affect plant concentrations of N, P, K, S, Cu, Mo, Zn or Cu except that the omission of Mo resulted in extremely low levels of Mo at some sites, particularly 7, 8, 9 and 10 (Appendix 4).

While there was no treatment affect of K on yield there were some site differences in K concentrations and a marked affect of year, particularly at Sites 1, 4, 7, 8, 9 and 10 (Appendix 4).

DISCUSSION

Basal Phosphorus and Sulfur

The over-riding response was to the application of basal P and S fertilisers, and only two of the sites, Site 5 and Site 6 produced fair yields without added basal fertilisers with Site 6 clearly the best site. These sites both had 6 ppm available P in the 0-10 cm soil layer, while Site 5 had 4 ppm S compared with 6 ppm for Site 6. The other 8 sites had available P levels of 2-6 and available S levels of 1-8 ppm.

On these yellow earth soils, P is the primary deficiency (authors, unpublished data) and Verano only responds to S in the presence of P. Site 6 appears to be the only site where available P and S levels are both adequate for Verano, that is both 6 ppm. Sites 5 and 7, with a similar soil available P level but lower S did not give the same growth responses.

At all sites Verano yields were good when P and S were applied, although there were differences between sites which may be related to soil physical characteristics.

Plant P concentrations were always below the critical levels published for various *Stylosanthes* species by Smith (1986) (Appendix 4). The only other published critical value for *Stylosanthes* is 34 ppm for pre flowering *S.humilis* (Andrew *et al* 1981). Values of 12-14 ppm for sub-clover (Brennan and Gartrell 1986) and 10 ppm for Verano (M A Gilbert, personal communication) and 0.30% at 41 days declining to 0.09% at 77 days for Siratro (*Macroptilium atropurpureum*, Johansen *et al* 1980) have been suggested. As the Verano in this trial had flowered by the time of harvest and was often at slightly different stages of flowering at different sites, the plant levels presented can not be used to determine critical levels. The main effects on P levels were recent application of fertilisers and site.

A critical value of .12% S at flowering has been suggested by Probert and Jones (1982). Based on this value, sulphur levels were adequate in plants from fertilised plots in the year of application but dropped to the level of the Nil plots by the following year (Table 6 and Appendix 4). As with P, S concentrations were affected by recent fertiliser applications, site and slightly different stages of maturity at different sites.

Zinc

Over the 10 sites, Zn omissions resulted in yields 10% lower than the All treatment. The yield reductions were significant and severe at only 2 sites, Site 8 (31%) and Site 10 (21%). The yield reductions were not significant at Site 3 (8%), Site 5 (15%) and Site 9 (15%).

The 5 kg/ha of Zn applied in this trial was adequate to overcome the deficiency for 4 years, and would be an inexpensive precaution against a deficiency on these soils. The deficiency was related to plant zinc levels of 10 ppm or lower and to soil extractable zinc levels of 0.8-1.0 ppm in the 0-10 cm layer except at Site 3 (response, 3.2 ppm), Site 7 (no response 1.0 ppm), Site 9 (no response 0.8 ppm). The three sites where a positive response in dry matter occurred all have 30% or more gravel and medium-high or high sand content in the soil surface. The low plant Zn concentrations and significant difference in the yield rating in 1983 at Site 9 may be related to a temporary Zn deficiency observed in Cavalcade (*Centrosema pascurorum*) in another trial at the same site. In this trial, stunted growth and Zn deficiency symptoms were observed in January in a first year stand, but by the end of the wet season, the plants had recovered and there was no difference in dry matter yield. This phenomenon may be related to Zinc availability in the soil surface, but higher availability at depth.

Potassium

There was no effect of treatment on Verano yield or plant K concentration, with this legume tolerating tissue concentrations as low as .5-.6% K. An effect of season or year on plant K concentrations was recorded (Appendix 4). Five of the Sites, 3, 7, 8, 9 and 10 have low available K levels in the soil surface and two of them, Sites 7 and 10 (Appendix 1), have low levels through the profile. Over the 10 sites, mean K concentration dropped from 1.67 in 1983 to 1.15 in 1986. There was a marked drop at Site 7 in 1985 and at sites 1, 2, 3, 4, 7, 8, 9 and 10 in 1986. The drop in 1986 is related mainly to the low rainfall which reduced capacity of the soils to re-supply the available pool during the wet season, but partly to an apparent run-down in soil K due to removal from the plots, particularly at Sites 7, 8, and 10 where the levels drop in 1985. This suggests that if there was repeated removal of K in hay from pastures grown on these soils that applications of K fertilisers could be required on some of the soils after 5-10 years. This affect is similar to that reported in pangola grass (*Digitaria decumbens*) hay paddocks in the Top End where poorly fertilised paddocks have low yields and show symptoms of K deficiency in dry years.

At the two sites with the highest available soil K levels, Sites 5 and 6 there was no apparent effect of year or removal on plant levels.

Molybdenum

As with K no response in yield was recorded with Mo. While a marked increase in plant Mo concentration occurred when Mo was applied (Appendix 4) this was not reflected in plant yields. Verano appears to be able to tolerate Mo tissue concentrations as low as .1-.4 ppm. The other difference in Mo concentrations is related to sites with levels being consistently lower at Sites 7, 8, 9 and 10 compared with the other 6 sites.

Site/Soil variability

These are not a uniform group of soils, even though they are all classified as yellow earths. There is considerable variability between and within the sites.

While significant differences between the sites in rooting depth, gravel and sand content available P, K, S and Zn levels and their ability to grow pasture legumes without fertiliser are documented, good legume yields can be achieved at most of the sites with the application of phosphorus and sulphur, and at all sites with the application of zinc as well.

Within the sites significant differences in yield ratings or dry matter yield between replicates at one or more sites were recorded in all four years. Significant differences between replicates at sites varied between years (1983:5, 1984:4, 1985:1, 1986:3), 3 year total yields (2 significant, 8 not), sites (Site 8:3 years; Sites 1, 5, 6:2 years, Sites; 4, 7, 9 and 10:1 year; Sites 2 and 3:0 years) and level of significance ($P<0.01$:6, $P<0.05$:7).

CONCLUSION

All of the soils/sites examined in this study are suitable for the growth of legume based improved pastures with the addition only of basal phosphorus and sulphur fertilisers, only one site is suitable for legume based pastures without phosphorus and sulphur fertilisers. Some of the sites require the addition of zinc to maximise production. Potassium fertiliser may be required on some of the soils if they are used intensively and have a high removal of hay.

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APPENDIX 1: SOIL CHARACTERISTICS

A. SOIL CLASSIFICATION

Three classifications are presented for each soil, to provide a complete picture.

a. Northcote *et al* 1975
b. Aldrick and Robinson 1972
c. Lucas *et al* 1983 - all Yellow earths, Land Unit number presented.

Site 1
a. Moderately deep, mottled - sandy yellow massive earth
b. (Yellow to) lateritic podzolic
c. 5d

Site 2
a. Deep, mottled - loamy yellow massive earth. (150 mm)
b. Yellow earth - Elliott (15 gravel of depth)
c. 3f

Site 3
a. Deep, mottled - grey massive earth, (gravelly) over structured red clay and weathering siltstone (4.95 m)
b. (Yellow to) Lateritic podzolic
c. 5d

Site 4
a. Deep, mottled - yellow massive earth (gravelly) over weathered mottled siltstone and bands of structured red earth (7.25 m)
b. Yellow Podzolic
c. 5d/5e

Site 5
a. Deep, mottled loamy massive earth
b. Yellow Earth - Elliott
c. 3f

Site 6
a. Moderately deep, mottled-brown massive earth (gravelly B) over highly mottled BC (3.25 m)
b. Yellow Podzolic (Ejong to poor Elliott)
c. 5e

Site 7
a. Deep, yellow massive earth (gravelly) (Lighter surface) (1.60 m)
b. Yellow Earth - Ejong
c. 5f1/3f

Site 8

a. Deep, mottled-sandy yellow massive earth (gravelly) over clay then weather mottled D. (4.46 m)
b. Lateritic Podzolic (Florina)
c. 5d

Site 9

a. Deep - mottled-sandy yellow-grey massive earth (gravelly) over weathering mottled siltstone (7.37 m)
b. Lateritic Podzolic (Florina)
c. 5d

Site 10

a. Moderately deep - mottled sandy grey massive earth (gravelly)
b. Lateritic Podzolic (Florina)
c. 5d

B. Physical Characteristics

Site	Estimated Rooting Depth cm	Depth (cm)	Gravels %			Surface Sand
			Composite	Maximum	Minimum	
1	120	0-10	35	45	23	High
		10-20	48	54	18	
		50-60	59	61	53	
2	20	0-10	6	14	0	Low
		20-30	9	11	0	
		50-60	38	61	34	
3	70	0-5	34	51	29	Med/High
		20-30	50	83	47	
		50-60	55	75	55	
4	80	0-10	13	31	7	Med/Low
		20-30	17	29	15	
		50-60	14	33	7	
5	20	0-10	24	32	18	Med/Low
		20-30	30	36	25	
		50-60	29	33	26	
6	20	0-10	16	30	13	Low
		20-30	11	23	9	
		50-60	32	40	11	
7	60	0-10	4	5	0	Med/Low
		20-30	8	10	0	
		50-60	22	53	0	
8	40	0-10	54	69	44	Med/High
		20-30	58	68	57	
		80-90	44	55	30	
9	90	0-10	21	33	20	Med/High
		20-30	20	61	21	
		80-90	36	41	17	
10	55	0-10	30	50	10	High
		20-30	40	64	0	
		80-90	43	65	44	

Comments at sowing/first year

Site 1: Surface sandy
2: Surface greasy when wet
3: Nil
4: Nil
5: Nil
6: Good seedbed, water-stressed in April
7: Sticky when wet, drainage poor, water logged in hollows
8. Surface extremely gravelly, pea sized ironstone
9. Nil
10. Soil has sandy yellow patches, drainage poor, waterlogged in hollows.

C. SOIL AVAILABLE NUTRIENT ANALYSES (ppm)

Site	Depth (cm)	Extractable				
		P	S	K	Zn	Cu
1	0-10	3	6	59	5.6	1.0
	10-20	2	2	32	0.8	0.8
	50-60	2	1	46	0.5	0.9
2	0-10	4	8	104	2.7	2.6
	20-30	4	3	68	1.1	2.0
	50-60	7	2	109	1.0	1.1
3	0-5	4	3	50	3.2	3.0
	20-30	2	0	85	3.4	1.1
	50-60	4	0	192	0.7	1.0
4	0-10	4	5	85	1.5	1.7
	20-30	3	3	101	0.9	1.4
	50-60	4	2	188	0.9	0.8
5	0-10	6	4	118	0.7	2.2
	20-30	3	4	101	0.8	2.0
	50-60	4	1	178	0.3	0.8
6	0-10	6	6	188	1.4	4.5
	20-30	7	2	187	1.0	3.4
	50-60	8	1	189	1.0	0.6
7	0-10	6	4	41	1.0	2.6
	20-30	4	3	25	0.8	2.4
	50-60	3	0	26	0.6	1.2
8	0-10	5	2	47	1.0	1.4
	20-30	5	3	34	1.2	1.4
	80-90	2	3	99	0.8	1.0
9	0-10	2	1	42	0.8	0.8
	20-30	1	2	35	1.0	0.8
	80-90	4	3	84	0.6	0.6
10	0-10	3	2	34	0.8	0.8
	20-30	2	1	29	1.0	0.6
	80-90	3	1	71	1.2	0.8.

D. SOIL TOTAL NUTRIENT ANALYSES (ppm)

Site	Depth (cm)	P	K	S
1	0-10	263	1420	122
	10-20	225	1320	1009
	50-60	315	4020	244
2	0-10	331	6680	5742
	20-30	268	6700	191
	50-60	349	7900	70
3	0-5	289	3180	52
	20-30	225	4100	17
	50-60	346	9000	70
4	0-10	291	4140	174
	20-30	256	5360	52
	50-60	304	7100	122
5	0-10	264	5720	52
	20-30	372	7500	70
	50-60	458	8700	52
6	0-10	316	5000	122
	20-30	373	6000	243
	50-60	429	7400	18
7	0-10	269	1840	ND
	20-30	247	2560	35
	50-60	256	3460	157
8	0-10	230	1460	87
	20-30	112	1760	17
	80-90	344	7120	52
9	0-10	167	1200	104
	20-30	194	2000	35
	80-90	271	6520	18
10	0-10	313	1520	104
	20-30	251	1760	1131
	80-90	307	6240	122

APPENDIX 2: YIELD RATINGS 18-20/4/83

Scale 0-5

Site	Date Sown	Date Rated	Treatment							Site[+] Mean
			Nil	Bas*	All	-Zn	-K	-Mo	-Cu	
1	11/1	19	2.0	4.4	4.6	4.1	4.5	4.7	4.9	4.5
2	5/1	18	1.0	4.0	3.2	3.3	3.7	3.4	3.9	3.6
3	3/1	18	1.1	3.1	3.3	3.8	3.6	3.3	4.0	3.5
4	3-4/1	18	1.5	4.5	4.9	4.5	4.6	4.7	4.7	4.7
5	6/1	19	2.0	2.9	3.5	3.3	3.3	3.3	3.4	3.3
6	11/1	19	3.7	4.8	4.9	4.9	4.9	4.6	4.7	4.8
7	12/1	19	1.4	3.2	3.8	3.6	3.5	3.4	3.5	3.5
8	13/1	19	1.2	3.6	4.2	3.6	4.2	4.2	4.3	4.0
9	17/1	20	1.4	3.8	4.8	4.1	4.5	4.8	4.9	4.5
10	13/1	20	1.4	3.7	3.6	2.7	3.7	3.3	4.0	3.5
Tr Mean	-	-	1.7	3.7	4.1	3.8	4.1	4.0	4.2	-

* Bas - Basal, P and S applied only

\+ Mean of plots receiving and P and S

APPENDIX 3: DRY MATTER YIELD S (Kg/ha) FOR YEARS 1984-1986

A: 1984 Dry Matter Yield

Site	Treatment							Site Mean +
	Nil	Bas *	All	-Zn	-K	-Mo	-Cu	
1	1730	7110	6250	6900	5990	5800	6090	6360
2	1620	5920	6320	6330	6410	7050	6650	6440
3	1770	5170	5110	5690	4090	5640	5440	5190
4	2460	8070	7070	6800	7200	7460	6890	7250
5	3130	6640	7340	6620	5910	6070	7270	6640
6	3600	6510	7910	7140	6860	4940	7040	7070
7	1460	6290	5810	6140	5980	5840	5690	5960
8	1120	3700	4530	3700	4770	4900	5120	4450
9	1660	6320	8420	6510	7430	7360	6800	7120
10	2100	6880	7670	7010	7050	7180	7750	7260
Tr Mean	2070	6260	6640	6280	6170	6420	6560	-

* Bas - Basal, P and S applied only
\+ Mean of plots receiving and P and S

B: **1985 Dry Matter Yield**

Site	Treatment							Site Mean +
	Nil	Bas *	All	-Zn	-K	-Mo	-Cu	
1	1630	6510	8660	7400	7870	7860	7270	7590
2	390	7110	7300	6430	7090	6840	6900	6930
3	520	6140	7270	5440	7630	6670	7600	6790
4	1810	7290	7520	7150	7170	7280	7870	7380
5	3070	8150	9320	7710	8530	7990	7600	8210
6	4070	9060	8390	9410	8730	9560	9060	9030
7	570	7160	6500	7440	6940	6920	7080	7010
8	330	4780	6680	4430	6690	7300	8270	6360
9	1790	8740	8710	8050	9540	9990	8780	8970
10	960	6400	7060	5410	7450	7230	7680	6870
Tr Mean	1510	7130	7740	6880	7760	7760	7810	-

C: 1986 Dry Matter Yield

Site	Treatment							Site Mean +
	Nil	Bas *	All	-Zn	-K	-Mo	-Cu	
1	930	3620	4320	4050	4430	4400	4330	4190
2	270	4040	4040	5050	3980	4640	4140	4310
3	230	2380	3260	2810	3160	3200	3080	2980
4	770	4550	4780	4770	4730	3890	4180	4480
5	1580	4930	6330	5400	5830	6140	6450	5850
6	2700	5390	5960	5310	5980	5920	5490	5670
7	550	4420	5570	4780	4400	4330	5140	4770
8	200	1700	3920	2250	3570	3520	4420	3230
9	330	4450	5950	5020	5150	5270	5390	5200
10	110	1780	1930	760	2350	3010	3140	2160
Tr Mean	770	730	4610	4020	4360	4430	4580	-

D: 3 YEAR TOTAL Dry Matter Yield - 1984 - 86

Site	Treatment							Site Mean +
	Nil	Bas *	All	-Zn	-K	-Mo	-Cu	
1	4290	17240	19230	18350	18290	18060	17690	18140
2	2270	17060	17660	17220	17490	18530	17680	17690
3	2520	14100	15050	13870	14070	15500	16120	14780
4	4990	19900	19370	18720	19110	18630	18940	19110
5	7790	19710	22990	19570	20260	20210	21320	20680
6	10370	20750	22260	21850	21580	22410	21603	21740
7	2580	17870	17880	18360	17310	17090	17910	17740
8	1650	10180	15130	10380	15030	15720	17810	14040
9	3770	19500	23090	19570	22110	22610	20980	21310
10	3150	15070	16670	13180	16850	17590	18900	16380
Tr Mean	4340	17140	18930	17110	18210	18740	18900	-

E: TOTAL YIELDS FROM 1984-86 AS A PERCENTAGE OF THE ALL TREATMENT YIELD

Site	Treatment					
	Nil	**Bas**	**-Zn**	**-K**	**-Mo**	**-Cu**
1	22.3	89.7	95.4	95.1	93.9	92.0
2	12.9	96.6	97.5	97.0	104.3	99.5
3	16.7	93.7	92.2	93.5	103.0	107.1
4	25.8	102.7	96.6	98.7	96.1	97.8
5	33.9	85.7	85.1	88.1	87.9	92.7
6	46.6	93.2	98.1	96.9	100.7	97.0
7	14.4	99.9	102.7	96.8	95.6	100.2
8	10.9	67.3	68.6	99.3	103.9	117.7
9	16.3	84.5	84.8	95.8	97.9	90.9
10	18.9	90.4	79.1	101.1	105.5	113.4
Tr Mean	22.9	90.5	90.4	96.2	99.0	99.8

F: RANKING OF THE SITES FOR YIELD 1983-86 - NIL FERTILISER PLOTS

Site	Rating 1983	Yields				84-86% of Highest
		1984	1985	1986	1984-86	
1	2.5	6	5	3	4	41.4
2	9	8	9	7	9	21.9
3	8	5	8	8	8	24.3
4	4	3	3	4	3	48.1
5	2.5	2	2	2	2	75.1
6	1	1	1	1	1	100.0
7	6	9	7	5	7	24.9
8	7	10	10	9	10	15.9
9	6	7	4	6	5	36.4
10	6	4	6	10	6	30.4

G: RANKING OF THE SITES FOR YIELD 1983-86 - PLOTS RECEIVING P AND S

Site	Rating	Yields				84-86% of Highest
		1984	1985	1986	1984-86	
1	3.5	7	4	7	5	83.4
2	6	6	7	6	6	81.4
3	8	9	9	9	9	68.0
4	2	2	5	5	4	87.9
5	10	5	3	1	3	95.1
6	1	4	1	2	1	100.0
7	8	8	6	4	7	81.6
8	5	10	10	8	10	64.6
9	3.5	3	2	3	2	98.0
10	8	1	8	10	8	75.3

APPENDIX 4: PLANT NUTRIENT CONCENTRATIONS 1983 - 1986

A: MEAN P% - NIL TREATMENT

Site	1983 * 18-20/4	1984 13/3-10/4	1985 * 4-12/3	1986 3-6/3	Mean
1	.07	.07	.08	.07	.07
2	.07	.06	.07	.08	.07
3	.08	.06	.06	.05	.06
4	.08	.05	.06	.06	.06
5	.08	.07	.09	.08	.08
6	.11	.08	.09	.09	.09
7	.06	.07	.06	.07	.07
8	.09	.05	.05	.07	.07
9	.08	.04	.05	.06	.06
10	.07	.05	.07	.08	.06
Mean	**.08**	**.06**	**.07**	**.07**	**.07**

* Fertiliser was applied in 1983 and 1985

B: MEAN P% - PLOTS WITH P AND S APPLIED

Site	1983	1984	1985	1986	Mean
1	.10	.07	.13	.09	.10
2	.08	.07	.11	.07	.08
3	.08	.06	.10	.07	.08
4	.10	.06	.12	.08	.09
5	.10	.08	.11	.09	.11
6	.13	.09	.13	.10	.11
7	.09	.08	.12	.08	.10
8	.11	.06	.12	.09	.09
9	.11	.06	.10	.07	.08
10	.11	.06	.14	.10	.10
Mean	**.10**	**.07**	**.12**	**.09**	**.09**

C: MEAN S% - NIL TREATMENT

Site	1983	1984	1985	1986	Mean
1	.08	.07	.07	.05	.07
2	.09	.09	.10	.10	.09
3	.11	.09	.11	.08	.10
4	.09	.07	.07	.08	.08
5	.09	.10	.08	.06	.08
6	.07	.07	.06	.07	.07
7	.11	.11	.10	.11	.10
8	.13	.11	.11	.13	.12
9	.11	.08	.10	.09	.10
10	.10	.09	.05	.07	.07
Mean	**.09**	**.08**	**.09**	**.08**	**.09**

D: MEAN P% - PLOTS WITH P AND S APPLIED

Site	1983	1984	1985	1986	Mean
1	.12	.07	.09	.07	.08
2	.11	.09	.13	.09	.11
3	.12	.09	.10	.07	.09
4	.11	.07	.12	.08	.09
5	.12	.10	.13	.08	.10
6	.12	.07	.10	.07	.09
7	.13	.11	.13	.09	.11
8	.13	.11	.13	.10	.11
9	.12	.08	.10	.08	.09
10	.13	.09	.12	.09	.10
Mean	**.12**	**.09**	**.12**	**.08**	**.10**

E: RANGES OF OTHER NUTRIENTS BY SITE
(Ranges over 4 years, containing > 95% of samples)

Site	Nutrient					
	N%	K%	Ca%	Mg%	Cu ppm	Mo ppm
1	1.2-2.2	.8-1.9	.8-1.8	.15-3.4	4-8	.3-4.6
2	1.3-2.2	1.3-1.9	.9-1.3	.12-..21	5-9	.2-2.4
3	1.3-2.3	1.1-1.9	.7-1.5	.12-.28	5-12	.3-2.9
4	1.3-2.2	.9-1.9	.8-1.3	.11-.30	3.10	.4-3.0
5	1.3-2.5	1.3-2.3	.6-1.4	.12-.28	5.-10	.1-3.3
6	1.2-2.5	1.1-2.4	.8-1.7	.12-.26	4-14	.3-4.6
7	1.4-2.5	.5-1.8	1.2-1.7	.21-.39	5-10	.1-1.8
8	1.4-2.5	.9-2.1	.8-1.6	.13-.29	5-12	.1-2.0
9	1.2-2.4	.6-1.9	.6-1.2	.10-.24	4.12	.2-2.2
10	1.4-2.4	.6-1.8	.5-1.1	.16-.43	4-13	.1-3.3
Nutrient Range	1.2-2.5	.5-2.4	.5-1.8	.10-.43	3-14	.1-4.6

F: RANGES OF OTHER NUTRIENTS BY YEAR
(Ranges over 10 Sites, containing > 95% of samples)

Site	Year			
	1983	1984	1985	1986
N	1.6-2.5	1.2-2.2	1.3-2.1	1.2-1.8
K	1.3-2.4	1.1-2.3	.5-2.0	.5-1.8
Ca	-	.7-1.8	.6-1.7	.5-1.6
Mg	-	.10-.36	.12-.43	.12-.43
Cu	5.9	3-10	5-12	4.14
Mo	-	.1-4.6		.1-3.0

G: POTASSIUM CONCENTRATION (%) BY SITE AND YEAR

Site	Year				Site Mean +
	1983	1984	1985	1986	
1	1.49	1.62	1.56	.98	1.40
2	1.63	1.66	1.60	1.46	1.58
3	1.64	1.55	1.47	1.28	1.46
4	1.76	1.45	1.40	1.15	1.39
5	1.67	1.81	1.41	1.58	1.61
6	2.00	1.43	1.22	1.49	1.45
7	1.35	1.36	.81	.69	1.00
8	1.81	1.81	1.44	1.16	1.52
9	1.67	1.23	1.48	.83	1.26
10	1.66	1.39	1.28	.87	1.25
Mean	1.67	1.53	1.36	1.15	1.39

H: MOLYBDENUM CONCENTRATION (ppm) BY SITE AND TREATMENT

(Mean of 2 years 1984, 1986 except for Sites 4 and 9 - analysed in 1986 only)

Site	Treatment				Site		
	Nil	Bas	-Mo	All	2 year	1984	1986
1	1.0	.5	.4	3.5	1.9	2.8	1.0
2	1.1	.6	.4	1.4	.9	.8	1.0
3	.7	.6	.5	2.1	1.1	1.1	.9
4	1.2	.8	.6	2.2	1.2	-	1.2
5	.9	.4	.3	2.5	1.0	1.1	.9
6	1.6	.9	.8	2.2	1.4	2.1	.8
7	.4	.3	.4	1.1	.6	.6	.5
8	.4	.2	.3	1.0	.5	.3	.8
9	.3	.3	.2	1.3	.5	-	.5
10	.4	.3	.2	2.0	.8	.9	.7
Treatment Means (2 year)	.8	.5	.4	2.0	1.0	.8	1.2
1984	9	.5	.5	2.4	-	-	-
1986	.8	.5	.4	1.6	-	-	-