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STUDIES ON THE NUTRIENT STATUS OF SOME TOBACCO SOILS IN FAR NORTH QUEENSLAND

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SUMMARY

Virgin and cultivated soils were examined for deficiencies of macro- and micro-nutrients, using the tomato as a test plant.

Results showed generally a deficiency of both nitrogen and phosphorus in virgin and cultivated soils. A sulphur deficiency was shown in five of the virgin soils but not in those under cultivation. Deficiencies of magnesium and manganese were recorded in one cultivated soil and of iron and copper in another. Deficiencies were measured in terms of dry weight of the aerial parts of the indicator plants.

I. INTRODUCTION

The Mareeba-Dimbulah irrigation area is an important area for flue-cured tobacco production. The climate can be described as dry tropical. Average annual rainfall ranges from 35 in. at Mareeba to 28 in. at Dimbulah. Approximately 83% of the rainfall is received between December and March.

A complex pattern of soil types occurs and detailed surveys of these have been made (unpublished reports of the Queensland Department of Primary Industries). A survey of the nutrient status of these soils is being undertaken to determine, primarily, what deficiencies other than those of nitrogen, phosphorus and potassium are present. The survey was designed as an initial step in nutritional investigations as they apply to individual soil types.

Information available on the nutrient status of these soils is limited. Analysis of cured tobacco leaf for nitrogen, molybdenum, zinc and chlorine (Chippendale 1954) showed that the molybdenum and zinc contents of Mareeba leaf tended to be low. This present paper is the first of a series to evaluate the availability of nutrients in individual soil types.

II. METHODS AND MATERIALS

Soil fertility was assessed by a subtractive-type pot technique. This involved the growing of a suitable indicator plant (tomato) in potted soil to which was added different nutrient solutions.

Two trials, one on virgin soil and the other on cultivated soil, were conducted on soils of the types described briefly in Table 1. Except for soil type 92, which had been cultivated in alternate years since the 1930s, cultivation had been limited to a few seasons.

TABLE 1

Brief Description of Soil Types Studied

Mareeba–Dimbulah area—North Queensland

Soil Type	Parent Material	Topography	Drainage	Soil Surface Colour and Approx. Depth
41. Dimbulah sandy loam ..	Granitic	Hill slopes	Good	Light brown (0–4 in.)
13. Morganbury loamy sand	Granitic	Hill slopes	Good	Light reddish brown (0–8 in.)
13g. Morganbury loamy sand (gravelly phase)	Granitic	Hill slopes	Good	Light reddish brown (0–6 in.)
21N. Nullinga loamy sand ..	Granitic	Hill slopes	Fair	Light grey (0–4 in.)
141. Emerald Creek sand ..	Metamorphic	Hill slopes	Good	Red brown (0–7 in.)
10. Mapee clay loam ..	Basaltic	Flat	Good	Dark reddish brown (0–8 in.)
2. Walkamin clay loam ..	Basaltic	Flat	Impeded	Greyish brown (0–12 in.)
43. Walsh sandy clay loam ..	Alluvial	Levee	Slow-impeded	Light brown (0–12 in.)
92. Barron loamy sand ..	Alluvial	Levee	Slow	Greyish brown (0–10 in.)

Studies were conducted at Parada Research Station under glasshouse conditions, using a randomized block design incorporating 15 treatments per trial.

Nutrient solutions were based on the Long Ashton formula as outlined by Hewitt (1952), except that iron chelate (NaFe) was substituted for ferric citrate and chlorine was not included. The control or complete solution was made up with distilled water, using the following analytical reagents:

Chemical	g/l	p.p.m.
KNO_3	0·505	K 195, N 70
$Ca(NO_3)_2.4H_2O$	1·180	Ca 200, N 140
$NaH_2PO_4.2H_2O$	0·234	P 46
$MgSO_4.7H_2O$	0·369	Mg 36, S 48
Iron chelate	0·355	Fe 2·6
H_3BO_3	0·00186	B 0·33
$MnSO_4.4H_2O$	0·00223	Mn 0·55
$ZnSO_4.7H_2O$	0·00029	Zn 0·065
$CuSO_4.5H_2O$	0·00025	Cu 0·064
$(NH_4)_6Mo_7O_{24}.4H_2O$ ..	0·00035	Mo 0·019
$CoSO_4.7H_2O$	0·000028	Co 0·006

The remaining nutrient solutions were made up by omitting or, where necessary, substituting for the appropriate chemical reagent. The complete or control treatment included 13 elements, namely N, P, K, Ca, Mg, S, Fe, Zn, B, Mn, Mo, Cu, and Co. In a second treatment no nutrients were applied. The remaining treatments consisted of all but one element, a different element being omitted per treatment. In this manner the availability of individual elements per soil type was assessed.

In these preliminary soil studies the tomato variety Q3, a strain of Valiant, was used as the indicator plant as it has a reasonably high requirement for most elements (Hewitt 1952) and is a plant whose deficiency symptoms have been described fully (Wallace 1961).

Composite soil samples were collected with a 4-in. diam. auger from both virgin and cultivated areas within the 0-12 in. depth of each soil type. Prior to potting, the sample was ground, sieved, fumigated and thoroughly mixed. Containers consisted of free-draining 4-in. diam. plastic pots. Approximately 500 g of air-dry soil was weighed into each pot.

The procedure of sowing tomato seed into a portion of the soil to be studied and then transplanting one seedling at the cotyledon stage into each pot was found to be the most suitable. Once the plants had become established, nutrient solutions were applied at weekly intervals, a 50-ml aliquot of the appropriate solution being given to each pot. Normal daily waterings were made with distilled water. Positions of pots were re-randomized at regular intervals.

During the growing period, observations on deficiency symptoms were recorded, the observations being based on the descriptions as outlined by Wallace (1961). Plants were harvested at ground level when those receiving the complete nutrient solution had produced at least five compound leaves over 1 in. long, the stage being determined by the nature of the technique used and the size of the pot. It was observed that at harvest the roots of complete nutrient or control plants were well distributed throughout the soil. Yields of plant tops were compared on an oven-dry weight basis. Nutrient deficiencies per trial were defined in terms of yield differences significantly less than the yield from the complete nutrient solution treatment.

III. RESULTS

The individual trials varied in duration from 4 to 7 weeks, the period depending largely on soil type. At harvest, control plants were 12–15 cm high and yielded approximately 1 g of oven-dry material per plant.

Results of studies on virgin soils (Table 2) showed a pronounced decrease in yield in the minus N treatments, significant at the 1% level. For the minus P treatments all yields were lower (1% level) than the control with the exception of the two soils of basaltic origin. Of these, the Mapee clay loam (type 10) showed no decrease in yield, while for soil type 2 a yield decrease significant at the 5% level was recorded. A sulphur deficiency was measured in five of the trials but this did not appear to be related to any particular group of soils. All nil treatments yielded significantly less (1% level) than the control.

TABLE 2

NUTRIENT DEFICIENCIES OF VIRGIN SOILS

Soil Type	Yield Percentage*				L.S.D. †	
	–N	–P	–S	Nil	5%	1%
41. Dimbulah sandy loam	25	12	15	12	37	50
13. Morganbury loamy sand	29	25	95	26	26	35
13g. Morganbury loamy sand (gravelly phase)	11	2	22	2	34	46
21N. Nullinga loamy sand	26	19	62	26	14	16
141. Emerald Creek sand	9	2	66	2	39	53
10. Mapee clay loam	27	81	76	30	38	51
2. Walkamin clay loam	2	53	30	2	38	51
43. Walsh sandy clay loam	14	6	59	11	30	40
92. Barron loamy sand	40	47	81	35	36	49

$$* \text{ Yield percentage} = \frac{\text{Yield for respective treatment}}{\text{Yield for all nutrients}} \times 100$$

† L.S.D. is quoted as a percentage of the yield from the complete nutrient treatment.

Typical nitrogen, phosphorus and sulphur deficiency symptoms were observed in plants where yield differences were measured in these virgin soils. The extent of root development at harvest for virgin soil of type 41 (Figure 1) indicated the effects of treatments in limiting root growth in minus N, minus P, minus S, and C (nil) treatments as compared with the control (T). It was noted that in the nil treatments a N or P deficiency symptom developed and this was related to the lower of the two yields measured in either the minus N or minus P treatments. Apart from nitrogen, phosphorus and sulphur, no deficiencies were observed for these virgin soils.

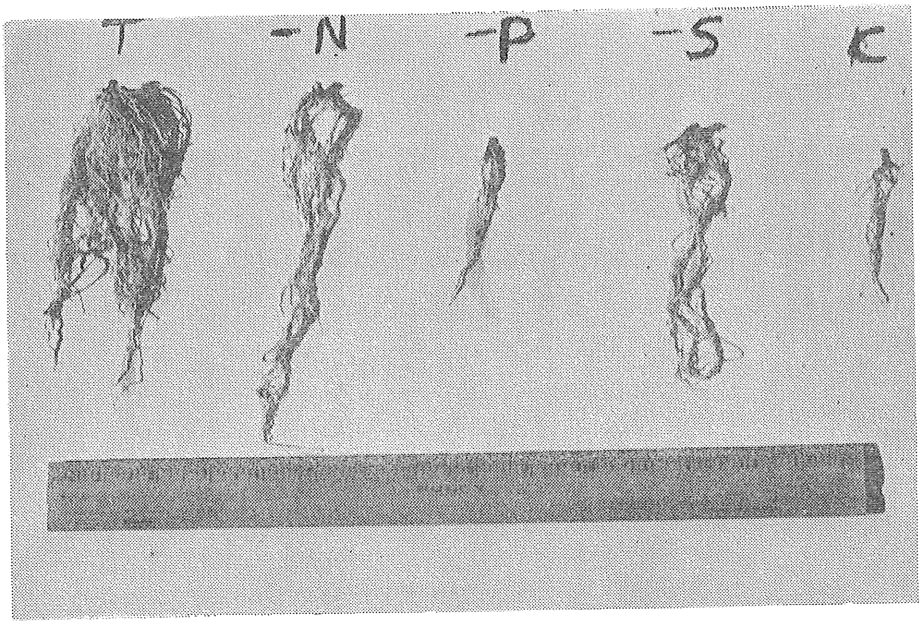

Fig. 1.—Root development at harvest per indicated treatment for virgin soil (type 41). (T = control; c = no nutrients).

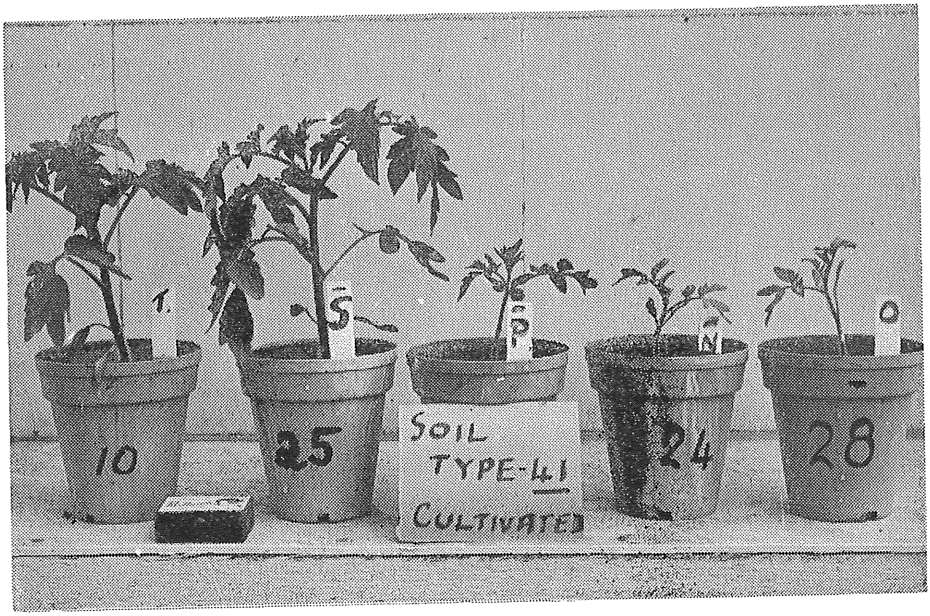

Fig. 2.—Observed nutrient deficiencies for cultivated soil. (T = complete nutrient solution). Note lack of deficiency in the minus S treatment.

In cultivated soils, plant deficiency symptoms were observed only in the minus N, minus P, and nil treatments (Figure 2). Again, symptoms exhibited by plants in the nil treatments were related to the lower yield of the minus N, and minus P treatments for each soil studied. Significant decreases in yield (1% level) were recorded in all minus N treatments with the exception of soil type 10. In this case, slight (N) deficiency symptoms were visible but the yield decrease (59% of the control) was not significant. Phosphate deficiencies were measured in six of the soils and in these instances deficiency symptoms were quite evident. No nutrient deficiency trends apart from nitrogen and phosphorus deficiencies were noted. Instances of Mg, Fe, Mn and Cu deficiencies were recorded (Table 3) when plant yields were compared. Sulphur was not limiting in any of the cultivated soils.

TABLE 3

NUTRIENT DEFICIENCIES OF CULTIVATED SOILS

Soil Type	Yield Percentage*							L.S.D.†	
	-N	-P	-Mg	-Fe	-Mn	-Cu	Nil	5%	1%
41	3	24	55	71	54	103	6	40	54
13	34	48	138	101	96	125	31	39	53
13g	17	67	90	100	96	92	17	53	71
21N	38	78	119	119	110	119	23	31	42
141	23	18	71	57	83	54	23	39	53
10	59	43	74	77	69	100	41	43	59
2	24	9	102	93	102	117	11	27	43
43	36	29	91	107	114	154	39	59	80
92	23	107	102	102	103	99	30	29	38

$$* \text{ Yield percentage} = \frac{\text{Yield for respective treatment}}{\text{Yield for all nutrients}} \times 100$$

† L.S.D. is quoted as a percentage of the yield from the complete nutrient treatment.

IV. DISCUSSION

Normal tobacco fertilizer applications in the Mareeba-Dimbulah area involve minimum rates of 10-15 lb nitrogen per acre, 26-44 lb phosphorus per acre and 50-80 lb potassium per acre. Of the cultivated soils, all except soil type 2 had grown tobacco within the two seasons prior to sampling. The two cultivated sites with the largest cropping histories were from soil types 13g and 92. The former had grown five tobacco crops during the previous 10 years, and the latter had been under tobacco cultivation in alternate years since the early 1930's. In none of the soils had cultivation and fertilizer practices raised the soil nitrogen status and in only a few cases was the soil phosphorus level adequate under the conditions of the experiment. Although no significant yield decrease in the minus N treatment of soil type 10 (cultivated) was measured, nitrogen deficiency symptoms were visible.

The limited evidence available would suggest that there had been a build-up in soil phosphorus with length of time under cultivation. The fact that phosphorus deficiencies recorded in virgin soils of types 13g and 92 were not evident in their cultivated counterparts would support this. The only other cultivated soil (type 21N) not giving a significant yield decrease in the minus P treatment did, however, display phosphorus deficiency symptoms in the indicator plants by the time of harvest. Results from these studies would indicate that, under short-term leys associated with several fertilized tobacco crops, there is a gradual build-up of soil phosphorus. This is feasible when it is considered that considerably less than one-third of the applied phosphorus is used by the crop. A reduction in phosphate application rate with increasing time of cultivation could be possible where tobacco monoculture has been practised.

Fertilizer practices had evidently been sufficient to raise the sulphur status of soils above a deficiency level, as no sulphur deficiencies occurred under cultivation. The total amount of sulphur absorbed by the tobacco plant has been reported to be approximately 9 lb/ac (Gizzard, Davies, and Kangas 1942). Present fertilizer usage, which normally includes single superphosphate (28% SO_3), would meet this demand. However, a trend towards the use of double or triple superphosphate or a completely soluble source of phosphorus could lead to the development of a sulphur deficiency. A tendency towards reducing the proportion of potassium sulphate in fertilizer mixtures could also deplete soil levels of sulphur.

Deficiencies of other elements were limited to two of the cultivated soils, soil types 41 (Mg and Mn) and 141 (Fe and Cu). Although significant yield differences (5% level) were recorded for these two soils, no deficiency symptoms were observed in the indicator plants. Field investigations would be required to examine the extent of these deficiencies in cultivated soils before remedial measures could be devised.

These nutrient studies indicate that the availability of the macro-elements N, P, K, Ca and S supplied by irrigation and fertilizer practices is adequate for crop requirements. The virtual absence of a magnesium deficiency indicates that this element is not limiting. That it is not limiting in cultivated soils could be attributed to recent practices of applying magnesium in addition to the normal N, P and K tobacco fertilizers. In regard to deficiencies of micro-nutrients, the results indicated that with the exception of two cultivated soils (types 41 and 141), no deficiencies were present. Commercial fertilizers can contain varying amounts of micro-nutrients, as reported by Swaine (1962). This could account for the lack of deficiencies recorded for cultivated soils. Limitations of the technique used, in the form of contamination particularly for molybdenum and cobalt, could have masked deficiencies of these nutrients. Although limitations do exist, the technique is advantageous in providing a comparatively economical and rapid method for screening soils for the presence of serious deficiencies of most plant nutrients.

The results indicate that apart from nitrogen, phosphorus and sulphur deficiencies in most of the virgin soils, and nitrogen, phosphorus, magnesium, iron, manganese and copper in some or all cultivated soils, no pronounced deficiencies were present under the conditions of the experiments.

V. ACKNOWLEDGEMENTS

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