

USE OF FERTILIZER IN COCONUT SEEDLING ESTABLISHMENT IN A GRASSLAND AREA OF NEW BRITAIN

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ABSTRACT

Regular applications of nitrogen + sulphur resulted in good coconut seedling growth and initial inflorescence production 4 years after transplanting of replants on a very old and sparse coconut stand in a grassland area. Additions of trace elements failed to produce any additional improvements in growth. Sole nitrogen applications were deleterious and caused the deaths of a quarter of the seedlings within 9 months of transplanting. Applications of sulphur alone had little beneficial effect initially, presumably due to low soil nitrogen levels. There were indications that after about 3 years, nitrogen applications may have become superfluous, as legume cover-crop became established at the trial site.

Foliar analyses showed gross nitrogen and sulphur deficiencies and nutrient uptake from fertilizer was clearly indicated.

A comparison of seedlings from two sources was inconclusive.

It is recommended that 4 oz of ammonium sulphate be applied about 6 weeks after transplanting with follow-up applications at the same rate 3, 9 and 12 months later. Rates should then be doubled and applied at 3-monthly intervals until palms are about 3 years old.

Recommendations for treatment after 3 years have yet to be established.

INTRODUCTION

Many coconut stands in New Guinea, especially those established before or soon after the turn of the century, are in need of replanting. Signs of senility are common and often stands are uneven and sparse. Some stands have been intercropped (often with cacao) but typically kunai (*Imperata cylindrica*) or other grasses form the ground cover.

Difficulties have arisen in replanting in such situations and also in establishing seedlings in grassland areas previously not planted with coconuts, especially in the Gazelle Peninsula of New Britain.

Fires are common in grassland areas and these, combined with heavy rainfall and leaching, are likely to lead to low nitrogen levels especially as the legume component of such areas is usually negligible. Additionally, investigations

by the Department of Agriculture, Stock and Fisheries have revealed a widespread sulphur deficiency in the Gazelle Peninsula and other widely separated parts of Papua New Guinea.

Southern (1967) indicated that the sulphur deficiency is more likely to be ecological than pedological as it has been noted on a variety of soil types varying from deep mature tropical latosols to immature volcanic and alluvial soils. High rainfall and heavy leaching, often combined with periodical grassfires and sometimes prolonged cropping, are likely to lead to low soil sulphur levels. Furthermore severe competition from grasses on soils low in sulphur is likely to decrease sulphur availability to seedlings.

It is noted that sulphur deficiency is not confined to grassland areas but has also occurred in coconuts interplanted with cacao. Prolonged cropping under such conditions is a likely cause of sulphur deficiency.

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If seedlings are to be established successfully there is an obvious need for a suitable fertilizer programme where nitrogen and sulphur deficiencies are expected. A fertilizer trial was therefore established on a commercial plantation near Kokopo in conjunction with a programme of replanting by the owners.

EXPERIMENTAL METHODS

Site

The trial was located on an area of grass-land, which supported a very sparse stand of coconuts reputedly over 80 years old. Less than 10 per cent of the original stand remained and palms were very tall with few nuts and showed typical sulphur deficiency symptoms (as described by Southern 1967). The cover was mainly *Imperata cylindrica*, and *Sorghum pro-pinquum* with patches of *Pueraria phaseoloides* which the management was attempting to establish. The soil was a deep volcanic ash, well supplied with bases and phosphorus. The locality has one of the lowest rainfalls in the Gazelle Peninsula with an annual average of 71 in recorded over the 9 years from 1961-62 to 1969-70. A definite dry season occurs from May to November and during this period grassfires can be quite devastating.

Treatments

Treatments were as follows:—

- T1—control (unfertilized);
- T2—nitrogen (4 oz urea at transplanting);
- T3—sulphur (4 oz elemental sulphur at transplanting);
- T4—nitrogen + sulphur (rates as for T2 and T3);
- T5—nitrogen + sulphur + trace element mixture (same rates as for nitrogen + sulphur and 2 oz trace mixture); and
- T6—same as T5 but using an alternative seed source.

Fertilizer was initially applied to Treatments 1 to 5 within a week of field-planting and subsequently at the same rate 3 and 6 months later. Thereafter fertilizer was applied at double the initial rates at 6-monthly intervals. Treatment 6 was first fertilized 6 weeks after transplanting and thereafter in conjunction with the other treatments.

Selected seednuts from a source in the Gazelle Peninsula customarily used by the plantation owners were used for the first five treatments, while seed from the plantation itself was used in the last treatment. Seednuts from the local source could be expected to be low in sulphur and this feature was considered worth studying.

Nurseries were established in October, 1965 and seedlings were field-planted in May, 1966 into holes averaging $2\frac{1}{2}$ ft x $2\frac{1}{2}$ ft x $2\frac{1}{2}$ ft according to the owner's policy. Fertilizer was sprinkled evenly over and around the planting holes.

A randomized block design with three replicates was used. Each plot consisted of 25 seedlings planted on a 27 ft triangular spacing with a single untreated guard row between plots.

By November, 1969 (some $3\frac{1}{2}$ years after transplanting) there were indications that further additions of nitrogen might be superfluous. Plots of Treatments 3, 4, 5 and 6 were split to enable a nitrogen + sulphur and sulphur alone comparison to be made. The 12 paired plots so formed should allow fairly high precision with covariance on pre-treatment records. Plots were split, with the short diagonal as guard, to give triangular plots of ten palms. Poaching was not expected to be a problem for a couple of years. In May, 1970 nitrogen rates were increased to 2 lb of urea a year comprising 3-monthly applications of $\frac{1}{2}$ lb each.

Recordings

The following records were taken:—

1. Heights at regular intervals until November, 1968, when measurements became impractical;
2. Frond production at regular intervals;
3. Colour—scored, using the scale below, 6 and 9 months after transplanting—
 - 5 = green;
 - 4 = yellow-green;
 - 3 = green-yellow;
 - 2 = yellow;
 - 1 = very yellow to orange;

4. Frond samples for chemical analysis were collected 6, 10, 24 and 36 months after transplanting. On the first occasion the youngest fully opened fronds (designated the first) were sampled; on the second occasion the first and fourth fronds were sampled while on the last two occasions the fourth and ninth fronds were used.

Analyses were conducted by the Chemistry Branch of DASf at Port Moresby.

RESULTS

General Observations

Marked differences in seedling growth were noted within 6 months of transplanting. Seedlings treated with nitrogen only were stunted, very chlorotic and frequently displayed deformed fronds. Nine months after transplanting 24 per cent had died and the rest were doing very poorly. This treatment was discontinued and thereafter seedlings were supplemented with sulphur. Most of the seedlings recovered and grew quite well.

Seedlings fertilized solely with sulphur were initially quite inferior to those treated with nitrogen + sulphur but appeared to improve later (about 3 years after transplanting). It was postulated that nitrogen additions were no longer necessary after 3 years and alterations to the trial were made to examine this. It is possible that increased nitrogen availability may have occurred as a result of the *Pueraria* cover-crop spreading over about two-thirds of the trial.

Applications of sulphur + nitrogen produced good seedling growth while additions of trace elements failed to show any additional response. A small number of seedlings treated with sulphur + nitrogen flowered within 4 years of transplanting.

Seedlings derived from the plantation itself, although consistently behind those from the customary source, were not significantly inferior. The poor performance as a result of poorer maintenance of one of the three plots planted with local seed may have caused this lag.

It is too early yet to ascertain whether the change to sulphur alone after 3 years will show any difference from the continued use of sulphur + nitrogen.

Heights

Seedling heights to 30 months after field-planting are illustrated in the Figure.

Seedlings fertilized with nitrogen + sulphur were significantly ahead of the others within 9 months of transplanting. This trend continued and sulphur-treated seedlings also made better growth than unfertilized ones or those fertilized with nitrogen only. It is noted that from November, 1967 onwards, height increment of sulphur-treated palms equalled that of palms treated with both sulphur and nitrogen.

Frond Production

Cumulative frond numbers are shown in Table 1.

Table 1.—Average cumulative frond numbers to 3½ years after transplanting

Treatment	Time from Transplanting (Months)									
	3	6	9	12	15	18	24	30	36	42
T1	5.3	7.2	9.2	10.9	12.4	14.0	17.3	20.5	23.6	27.8
T2	5.3	7.3	9.2	10.6	12.3					
T3	5.3	7.2	9.2	11.0	12.7	14.4	18.4	22.1	26.3	32.0
T4	5.5	7.7	10.5	12.2	14.7	16.6	21.5	25.9	30.4	36.6
T5	5.2	7.7	10.3	12.3	14.3	17.0	21.7	25.9	31.4	38.3
T6	5.4	7.2	9.9	11.9	13.9	15.9	20.8	24.9	29.7	35.7
Least significant difference	5 per cent		0.7	0.9	1.1	1.6	1.9	2.5	3.2	4.7
	1 per cent		1.0	1.3	1.6	2.4	2.8	3.6	4.7	6.8

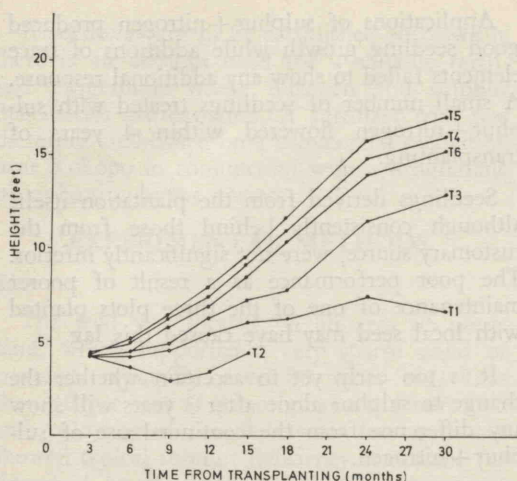


Figure.—Seedling heights to 30 months after transplanting

Seedlings treated with nitrogen and sulphur had produced significantly more fronds within 9 months of transplanting. Palms treated with sulphur alone produced more fronds than unfertilized palms, but up to November, 1969 the difference was not statistically significant. As the trial progressed, differences in frond production, between palms treated with sulphur and those treated with nitrogen + sulphur, diminished.

Colour

An assessment of seedling colour is shown in Table 2.

Table 2.—Colour assessments*

Treatment	Time from Transplanting (Months)	
	6	9
T1	3.53	3.65
T2	2.08	2.13
T3	4.32	3.81
T4	4.65	4.99
T5	4.71	4.99
T6	4.69	4.87
Least significant difference	5 per cent 0.45	0.36
	1 per cent 0.63	0.51

* See text for details of scoring for colour.

On both occasions seedlings treated with nitrogen + sulphur were a good colour while untreated seedlings and those receiving sulphur

alone varied in colour from green-yellow to yellow-green. A yellow or orange appearance was typical of palms treated with nitrogen only.

Chemical Analysis

Analyses for various elements are shown in Tables 3 and 4. The N, P, K, Ca and Mg determinations are on a percentage of dry matter basis while S, Mn, Fe, Cu and B are in parts per million.

At 6 and 9 months after transplanting, foliar analyses correlated well with treatments. Nitrogen levels in both the first and fourth fronds were low in unfertilized seedlings and consistently higher where nitrogen + sulphur had been added. In seedlings fertilized only with nitrogen, excessively high nitrogen levels reflected inadequate sulphur nutrition. Samplings

Table 4.—Analyses for nitrogen and sulphur 24 and 36 months after transplanting

Time from Transplanting	Frond	Treatment	N	S
24 months	4	1	2.03	93
	4	3	1.64	495
	4	4*	1.49	463
	4	5	1.71	313
	4	6	1.59	487
24 months	9	1	1.71	133
	9	3	1.38	348
	9	4	1.49	407
	9	5	1.54	267
	9	6	1.42	322
36 months	4	1	1.90	185
	4	3	1.72	422
	4	4	1.81	613
	4	5	1.92	617
	4	6	1.87	622
36 months	9†	1		
	9	3	1.47	372
	9	4	1.40	378
	9	5	1.61	527
	9	6	1.54	430

* Average of two replicates.

† Insufficient 9th fronds available for sampling.

24 and 36 months after transplanting did not indicate directly nitrogen uptake from fertilizer. Nitrogen levels tended to be lower in the sulphur + nitrogen treatments than in unfertilized seedlings but this possibly is a reflection of the superior growth of the former.

Sulphur levels correlated well with treatments over all the samplings.

Table 3.—Analyses 6 and 10 months after transplanting

Time from Transplanting	Fron	Treatment	N	P	K	Ca	Mg	S	Mn	Fe	Zn	Cu	B
6 months	1	1	1.67	0.183	2.11	0.33	0.33	93	39	24	16.3	4.0	15.2
	1	2	2.71	0.223	2.34	0.34	0.37	113	32	22	21.2	6.0	13.1
	1	3*	1.63	0.170	2.02	0.37	0.33	560	41	19	15.3	3.5	15.2
	1	4	2.08	0.179	1.91	0.33	0.31	223	38	22	16.1	4.7	12.4
	1	5	2.11	0.176	2.07	0.33	0.32	353	38	21	15.4	4.9	21.1
	1	6	2.08	0.175	2.02	0.33	0.33	260	36	23	16.4	5.0	18.4
10 months	1	1	1.58	0.232	1.78	0.29	0.51		20				
	1	2	3.08	0.267	1.99	0.31	0.50		36				
	1	3	1.59	0.221	2.32	0.31	0.50		26				
	1	4	1.77	0.212	2.08	0.28	0.44		35				
	1	5	1.74	0.212	2.34	0.26	0.43		31				
	1	6	1.74	0.208	2.31	0.29	0.46		32				
10 months	4	1	1.43	0.173	1.63	0.45	0.42		40				
	4	2	2.19	0.172	1.48	0.48	0.39		29				
	4	3	1.40	0.155	1.51	0.56	0.45		57				
	4	4	1.73	0.175	1.40	0.58	0.46		66				
	4	5	1.84	0.169	1.43	0.58	0.48		76				
	4	6	1.72	0.168	1.41	0.56	0.45		59				

* Average of two replicates.

DISCUSSION

Clearly, additions of nitrogen and sulphur are needed for successful seedling establishment in situations such as those described.

FronD nutrient studies indicated that sulphur and nitrogen were the only nutrients that required attention.

The gross nitrogen-sulphur imbalance caused by sole nitrogen applications is of considerable practical importance. The practice of fertilizing with urea or an NPK fertilizer (often low in sulphur) is by no means uncommon and where soils are deficient in sulphur, this would obviously be harmful. Instances of nitrogenous fertilizer causing nitrogen-sulphur imbalances have been reported with coconut seedlings on the Papuan coast (DASF 1969) as well as with tea and coffee in the New Guinea highlands.

The situation with seedlings fertilized with sulphur only is interesting. For the first 2 years or so sulphur alone appeared to have limited beneficial effect as responses were presumably limited by low soil nitrogen levels. Subsequently growth improved but due to the initial lag, overall development was still inferior to that of seedlings receiving both sulphur and nitrogen.

It is postulated that by virtue of their more extensive root system, 3-year-old seedlings are able to forage sufficient nitrogen from the soil. The spread of the *Pueraria* cover-crop over about two-thirds of the trial would have increased nitrogen availability both by reducing competition and through fixing nitrogen. Any future comparisons of sulphur+nitrogen and sulphur alone would be invalidated for typical grassland situations due to the spread of the legume.

Trace element applications failed to improve growth any further and chemical analyses 6 months after transplanting indicated satisfactory trace element nutrition. Further analyses were not considered necessary. It is noted, however, that Southern and Dick (1967) pointed out that analyses of young fronds would not necessarily detect deficiencies of manganese, iron or zinc. Even so the appearance of untreated palms and the lack of a significant growth response in treated palms suggested that additions of trace elements were unnecessary.

Seedlings from the local seed source tended to be a little behind the others, but as differences were not statistically significant, definite conclusions cannot be drawn. Perhaps the slight lag in the former can be attributed to the initial delay in applying fertilizer (especially if, in fact, the seednuts from the local source were inherently low in sulphur) or to inferior maintenance of one of the three plots planted with local seed.

Obviously, additions of nitrogen and sulphur effectively promoted seedling growth but the proximity of the rates used to the optimum level is not precisely known. Possibly, lower rates could have sufficed and more frequent applications may have been desirable.

Nitrogen and sulphur are usually supplied as ammonium sulphate in Papua New Guinea and on a cost basis this is slightly cheaper as well as more convenient. As a rough approximation, ammonium sulphate contains half the nitrogen and a quarter the sulphur found in the same weights of urea and elemental sulphur. With ammonium sulphate at \$70 a ton and urea and sulphur at \$100 and \$150 a ton respectively, it would cost approximately 25 per cent more to supply nitrogen and sulphur as urea and elemental sulphur than as ammonium sulphate. Availability and effectiveness of equivalent rates of ammonium sulphate or urea as sources of nitrogen would probably be similar under normal conditions; although initial availability of the sulphate anion from ammonium sulphate would be greater, losses through leaching from elemental sulphur may be less.

A previous experiment by the author (Sumbak 1970) with coconut seedlings up to 12 months from transplanting indicated that the effects of 4 oz doses of ammonium sulphate began to wear off within 3 months of application. Foliar analyses indicated that a drop in nitrogen levels rather than in sulphur caused this. More frequent applications of nitrogen, perhaps at lower rates, may be desirable but would be difficult to implement under present plantation conditions. The indication that high nitrogen levels increase susceptibility to *Helmintosporium* leaf spot disease (Sumbak 1971) rules out any recommendation for higher fertilizer rates for the first 12 months or so after transplanting.

A fertilizing programme aimed at providing seedlings with 8 oz of ammonium sulphate every 6 months was laid down by the owners of the plantation soon after the trial reported here was commenced. These palms grew reasonably well but not as well as those in the trial. Although the programme as laid down was not always adhered to exactly, it is likely that lower rates of nitrogen and sulphur limited growth.

RECOMMENDATIONS

It is suggested that under conditions similar to those in the trial area, 4 oz ammonium sulphate be applied about 6 weeks after transplanting followed by the same doses 3, 6 and 9 months later. Thereafter 8 oz every 3 months should be added until the palms are at least 3 years old. Under conditions such as those encountered in the trial, doses of elemental sulphur may be sufficient thereafter.

The materials cost of 2 lb of ammonium sulphate per palm amounts to approximately \$4.30 an acre every year. This is roughly equivalent to the same amount of nitrogen and half

as much sulphur as used in the trial reported and should be adequate for vigorous palm growth.

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