

FURTHER STUDIES IN COCONUT SEEDLING ESTABLISHMENT

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ABSTRACT

*In a volcanic ash soil that had previously been cropped and had shown a response to nitrogen and sulphur, complete weed control led to superior growth compared with the normal plantation practice of periodical slashing. Complete weed control was also much superior to merely clean-weeding a limited area around seedlings. Seedlings fertilized with ammonium sulphate in any of the clean-weeding treatments were more heavily attacked by *Helminthosporium incurvatum* than unfertilized seedlings and the growth of the latter was superior in all cases up to about one year after transplanting. At the end of the experiment fresh weight determinations showed that fertilized seedlings which had been subjected to limited clean-weeding were slightly heavier (despite the initial *H. incurvatum* damage) than unfertilized seedlings but that fertilized seedlings under complete clean-weeding remained inferior. There was an indication that under complete weed control a light mulch was beneficial.*

*Under slashing maintenance the fertilizer effect was reversed, with fertilized seedlings being more than twice as heavy at the end of the experiment. Increased susceptibility to *H. incurvatum* is apparently related to high nitrogen availability and it is postulated that severe weed competition in the slashed plots prevented nitrogen availability from becoming excessive when fertilizer was used.*

*It is suggested that lower nitrogen rates or possibly the use of sulphur alone may result in lowering of *H. incurvatum* damage.*

INTRODUCTION

THE advantages of adequate weed control during coconut seedling establishment on volcanic ash soils of the Gazelle Peninsula, New Britain, were demonstrated by Sumbak (1970). Seedlings in plots that were weeded by hand showed superior growth to those where weeds were merely slashed periodically. Regular slashing was superior to infrequent slashing. Under conditions of infrequent slashing growth was so poor that it was doubtful whether seedlings could be brought into production without fertilizer.

Weeds undoubtedly competed for nutrients, as good response to fertilizer occurred on slashed plots while clean-weeded plots showed less response. Fertilizer increased leaf sulphur content of seedlings in slashed plots very substantially while an uptake of nitrogen was also indicated. However, as fertilizer failed to raise

seedlings in either of the slashed treatments to the standard of unfertilized clean-weeded seedlings it was probable that competition for soil moisture and probably light were also of importance.

Complete weed control, which leaves the soil in sole coconut stands exposed, would at present be neither feasible nor desirable in Papua New Guinea. However, clean-weeding in a limited area around the base of the seedlings would be practicable. A trial was conducted to investigate the effectiveness of weed control over a restricted area around the base of the seedling and the usefulness of a light mulch as well as any interaction of fertilizer with various maintenance systems.

EXPERIMENTAL METHODS

Seedlings between the four-leaf and seven-leaf stage were transplanted in January, 1968. A 15ft spacing was used as it was intended to terminate the trial after two years and hence inter-seedling competition would be of little

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consequence. The trial area initially supported a cover mainly of *Sorghum propinquum* with limited amounts of kunai (*Imperata cylindrica*) and occasional plants of sweet potato (*Ipomoea batatas*) and taro (*Colocasia* sp.).

Treatments were as follows:—

T1—periodical slashing (about every 8 weeks).

T2—clean-weeding over a circle about 3 ft in diameter.

T3—clean-weeding over a circle about 6 ft in diameter.

T4—clean-weeding the entire plot.

T5—clean-weeding the entire plot and light mulching.

Clean weeding circles were increased to 4 ft and 8 ft respectively in February, 1969. Treatments involving clean weeding were carried out at intervals of from 4 to 5 weeks. For a period of 8 months (extending from June, 1968 to February, 1969) labourers used spades and bush knives to remove weeds instead of using the prescribed method of pulling weeds out by hand, shaking the soil loose and laying the uprooted weeds over the area from where they had been removed. When spades were used, weeds and some of the topsoil were thrown outside the clean-weeded circles. Aside from lessening nutrient availability it is possible that the root systems of seedlings may have suffered some mechanical damage. Hand-weeding was re-introduced in February, 1969 and strictly observed. Mulch was applied every 8 weeks and consisted of young *Sorghum propinquum* plants. About 15 lb of fresh material were applied to each seedling so that an area about 4 ft in diameter around the base of the seedling was well covered.

Fertilizer was applied to alternate seedlings, 1 month after transplanting and thereafter at 2-monthly intervals, at 4 oz ammonium sulphate per seedling. Rates were changed to 8 oz every 3 months in February, 1969.

Main plots consisted of 16 seedlings and each treatment was replicated four times.

Regular records of height and frond production were taken and fresh weights of the above-ground portion of the plants were obtained, 25 months after establishment for two

replicates and 26 months after establishment for the other two. It had been intended to keep two replicates growing but increasingly severe dynastid beetle damage forced an early conclusion to the trial.

RESULTS

Fungal attack, which undoubtedly contributed to the deaths of a number of seedlings and hindered the growth of others, added a complication to the trial as severity of damage appeared to be related to treatments. In the later stages dynastid beetle damage again complicated trial interpretation with the more advanced seedlings being more liable to attack. Results were assessed on an average per seedling basis.

Fungal Damage

Severe damage was noted in November, 1968 and the causal fungus was identified as *Helminthosporium incurvatum*. Damage appeared to be worst in the slashing treatments while the use of ammonium sulphate fertilizer in association with both complete or limited clean-weeding favoured fungal attack. Table 1 illustrates severity of damage on an average per seedling basis scoring the five youngest fronds of each seedling in the following scale:—

0 = uninfected.

1 = up to 25 per cent leaf area affected.

2 = 25 to 50 per cent.

3 = 50 to 75 per cent.

4 = 75 to 100 per cent.

5 = no functional leaf tissue.

Table 1.—Severity of *H. incurvatum* damage per seedling recorded in November, 1968*

Treatment	Fertilized	Unfertilized	Mean
T1	7.3	13.4	10.4
T2	14.4	8.7	11.6
T3	12.3	6.5	9.6
T4	13.4	5.5	9.5
T5	14.5	6.1	10.3

*See text for details of scoring for fungal damage.

An average rating was obtained by totalling the scores for each treatment and averaging.

A further examination in December, 1968, revealed numerous old leaf spots. Conidiophores resembling those of *H. incurvatum* were still present but no spores, and many other fungi, probably saprophytes, were also recorded on the old lesions. It was thought, at that stage, that much of the speckling of the green tissue with young lesions, not then sporulating, was due to a new cycle of infection by *H. incurvatum*. However, infestations as severe as the previous ones did not recur. The age of the seedlings or perhaps climatic effects and control measures adopted precluded severe damage. Control measures consisted of the removal and burning of severely affected fronds and spraying with copper oxychloride at 1 lb of ingredient to 29 gal of water.

Fungal damage was still evident in February and March, 1969 but it was not nearly as severe as the *H. incurvatum* damage encountered previously. Older fronds were typically affected (mainly frond positions 5, 6, 7 and 8) with only occasional infections on younger fronds. Symptoms were similar to those described by Shaw (1965) and attributed to *Pestalotiopsis palmarum* and *Pestalotiopsis theae*.

Another symptom which usually affected fronds from position 2 downwards was noted. Characteristically a blotchy yellowing and browning occurred at the base of leaflets usually well down the frond and gradually extended along the leaflets. The condition appeared to spread quite rapidly and affected tissue died quickly. The only fungus planted out from these lesions was a species of *Pestalotiopsis*. It was suspected that fungicidal sprays may have had a phytotoxic effect which may have favoured fungal infection. The suggestion of phytotoxicity arose from the observation that damage was first noticed at the base of leaflets and on the lower side where accumulation of liquids could be expected. The damage disappeared after about 6 weeks.

Although the initial heavy infestation by *H. incurvatum* was positively correlated with the use of ammonium sulphate fertilizer, later outbreaks mainly ascribable to species of *Pestalotiopsis* did not show a similar correlation with fertilizer use. Indeed a subjective assessment indicated less severe fungal damage where fertilizer was used under slashing and limited clean-weeding treatments.

Aside from contributing to seedling deaths fungal infestations weakened many seedlings. Seedlings were set back further by severe pruning of infected fronds as is illustrated in Table 2. Infected fronds were removed and burnt.

Seedling Deaths

Table 3 shows the number of deaths from the commencement of the trial in January, 1968 to mid February, 1969 (when most of the severe fungal damage was over) and total deaths from January, 1968 to March, 1970. There was initially a total of 32 seedlings in each sub-treatment.

Table 2.—Average number of fronds per surviving seedling in March, 1969

Treatment	Fertilized	Unfertilized
T1	4.70	3.13
T2	3.70	4.18
T3	4.25	4.34
T4	4.96	6.28
T5	4.21	6.47

During the first period the poor nutrient status of unfertilized palms in the slashed plots appeared to increase susceptibility to fungal damage which resulted in the death of almost half these seedlings. Fertilized palms in the other treatments were more heavily attacked by *H. incurvatum* than unfertilized and there were many deaths amongst heavily attacked seedlings. In the second period of the trial, 31 of the 54 deaths were associated with dynastid beetle attack, with 18 of these occurring in the completely clean-weeded plots.

Growth

Measurements of seedling heights and fronds production for February, 1969 and February, 1970 are shown in Tables 4 and 5.

Fresh weights of the above-ground portion of seedlings are shown in Table 6.

Plates I and II demonstrate the marked response to clean-weeding and mulching compared with ring-weeding only.

Table 3.—Total number of missing seedlings at various intervals after transplanting

Treatment	January, 1968 to February, 1969			January, 1968 to March, 1970			Percentage
	Fertilized	Unfertilized	Total	Fertilized	Unfertilized	Total	
T1	2	14	16	7	19	26	40.6
T2	6	3	9	12	8	20	32.3
T3	4	0	4	10	3	13	20.3
T4	3	4	7	9	13	22	34.4
T5	1	0	1	7	3	10	15.6
Total	16	21	37	45	46	91	28.6

Table 4.—Average seedling heights (ft) recorded in February, 1969 and February, 1970

Date	February, 1969*			February, 1970†		
Treatment	Fertilized	Unfertilized	Average	Fertilized	Unfertilized	Average
T1	6.00	3.47	4.73	13.47	8.95	11.21
T2	5.53	4.68	5.10	13.46	10.86	12.16
T3	5.76	4.25	5.25	12.57	10.20	11.39
T4	6.19	7.14	6.66	15.35	16.36	15.85
T5	5.91	6.67	6.29	16.32	17.58	16.95

* Least Significant Difference 5% 1.19 Maintenance treatment means.
1% 1.67

Least Significant Difference 5% 1.06 Same maintenance, different fertilizer levels.
1% 1.47

† Least Significant Difference 5% 3.36 Maintenance treatment means.
1% 4.70

Least Significant Difference 5% 1.88 Same maintenance, different fertilizer levels.
1% 2.60

Table 5.—Average cumulative frond production recorded in February, 1969 and February, 1970

Date	February, 1969			February, 1970*		
Treatment	Fertilized	Unfertilized	Average	Fertilized	Unfertilized	Average
T1	8.29	6.91	7.60	16.03	13.82	14.93
T2	7.67	7.67	7.67	16.89	15.61	16.25
T3	8.34	7.84	8.09	17.12	15.38	16.25
T4	8.89	9.39	9.14	18.38	19.17	18.77
T5	9.22	9.56	9.37	19.24	20.11	19.68

* Least Significant Difference 5% 2.29 Maintenance treatment means.
1% 3.21

Least Significant Difference 5% 1.19 Same maintenance, different fertilizer levels.
1% 1.64

Table 6.—Average fresh weight (lb) of above- ground portion of seedlings

Treatment	Fertilized	Unfertilized	Mean*
T1	88.0	39.5	63.8
T2	72.3	52.8	64.0
T3	81.0	51.3	66.1
T4	128.3	169.0	148.6
T5	157.3	205.8	181.5

* Least Significant Difference 5% 73.0 Maintenance treatment means.
1% 102.3

Least Significant Difference 5% 33.8 Same maintenance, different fertilizer levels.
1% 46.7

DISCUSSION

Maintenance Effects

Early growth measurements indicated that with ammonium sulphate fertilizer, differences between maintenance treatments were largely obviated, but without fertilizer, slashing or limited clean-weeding were inferior. However, as the experiment progressed the superiority of complete weed control to either slashing or limited clean-weeding became very marked and there was an indication that light mulching may also have been beneficial. Unfertilized seedlings which had been clean weeded and lightly mulched were more than twice as heavy as fertilized seedlings and five times as heavy as unfertilized ones where maintenance consisted solely of slashing. This is in general agreement with previous observations on maintenance effects (Sumbak 1970).



Plate I.—Treatment 5, unfertilized seedling 21 months after transplanting



Plate II.—Treatment 3, fertilized seedling 21 months after transplanting

The relatively poor performance of ring-weeded seedlings was somewhat surprising. Although incorrect weeding procedures for a portion of the trial may have been of some consequence it is more likely that poaching by weeds and competition with seedling roots outside the clean-weeded areas were of more importance. That limited clean-weeding had some effect was suggested by unfertilized seedlings in these treatments showing better growth than unfertilized slashed seedlings. This finding is of little practical value as growth in both cases was still unsatisfactory.

A good response to ammonium sulphate occurred under both limited clean-weeding and slashing but in the former case increased damage

by *H. incurvatum* over the first portion of the trials lessened the overall positive fertilizer effect.

Fertilizer decreased growth in the completely clean-weeded plots by increasing susceptibility to *H. incurvatum* attack, but the possibility of more appropriate fertilizer benefiting growth cannot be overruled. It is noted that a small positive response to a compound fertilizer (NPK supplemented by sulphur) was shown under clean-weeded conditions in a previous establishment trial (Sumbak 1970).

Disease Effects

H. incurvatum damage was severe to about 12 months after field planting with the intensity apparently related to the nutritional status of the seedlings. It is likely that the relatively high nitrogen availability and possibly its relation to sulphur supply influences susceptibility to this fungus. Russell (1961) noted that "excessive amounts of nitrogen give leaves with such large thin-walled cells that they are readily attacked by insects and fungus pests and harmed by unfavourable weather such as droughts and frosts." Under conditions encountered in this trial, nitrogen levels are likely to have been high where clean-weeding (to a greater or lesser extent) was combined with frequent ammonium sulphate applications. This appears to have favoured *H. incurvatum* attack.

The clear indication that fungal damage was more severe in unfertilized than in fertilized seedlings under slashing maintenance is somewhat puzzling. One would expect severe weed competition to change fertilizer effects but that an effect should be reversed is very surprising. A number of very tentative explanations are ventured.

Less severe damage to fertilized seedlings under slashing maintenance may possibly be explained by severe weed competition limiting nitrogen availability but leaving sufficient for reasonable growth. In other words nitrogen levels in seedlings were not sufficiently high to induce an increased susceptibility to fungal attack. A possible explanation for the poor performance of unfertilized seedlings is that low sulphur levels have led to unthriftiness and so increased susceptibility to fungal attack generally, and other fungi besides *H. incurvatum* may also have been of importance.

Further studies of nutrient availability under different maintenance systems and susceptibility to fungal attack are planned. Fertilizer types and rates under slashing and limited clean-weeding maintenance will be examined and work will not be limited to one site. Varietal reaction to fungal attack will also be noted.

The amounts of nitrogen applied are likely to be of importance. In a previous seedling establishment trial (Sumbak 1970) fungal attack caused some damage but there was no evidence of fertilizer increasing susceptibility to infestation. The amount of nitrogen supplied over the first 12 months to each seedling was 2 oz as compared to 5 oz in the current trial. In another establishment trial little fungal damage was evident on coconut seedlings fertilized with nitrogen and sulphur but a large number of deaths, and virtually no growth in seedlings fertilized with nitrogen only, caused the latter treatment to be abandoned. Maintenance involved infrequent slashing or rolling so in some respects it was similar to the current trial.

Damage due to *H. incurvatum* ceased to be a major problem about 12 months after transplanting but less severe damage attributed to *Pestalotiopsis* spp. and possibly other fungi continued throughout the duration of the trial. Towards the end fungal damage in the better-developed seedlings was negligible.

CONCLUSIONS

The practical implications of these findings are various. Where *H. incurvatum* is likely to be encountered it may be advisable to forgo clean-weeding around the seedlings, restrict maintenance to slashing and use ammonium sulphate fertilizer or possibly use restricted clean-weeding and reduce nitrogen application rates. It is also possible that where restricted clean-weeding is used additions of sulphur alone may suffice. The author recorded only a small response to sulphur without nitrogen in the first 2 years after transplanting in kunai (*Imperata cylindrica*) grassland conditions, but ring-weeding around the seedlings was not practised. Perhaps limited clean-weeding would ensure an adequate nitrogen supply which when supplemented by sulphur additions would allow good growth without increasing susceptibility to fungal damage.

Where *H. incurvatum* has not posed a problem in the past the use of ammonium sulphate combined with limited clean-weeding could well result in better growth than when maintenance is limited to slashing. This possibility and perhaps a reduction of nitrogen rates (or substituting sulphur) warrants investigation.

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INTRODUCTION

MINOR shrubby plant consisting of much less well drained dark clay soils occupy a small proportion of the coastal hill zone around Port Moresby. A recent estimate calculated that about 1500 ha of this soil type is present in the Port Moresby area. The vegetation is lowland forest, mainly open woodland. Although the soils are not extensive it was thought desirable to have some information as to their fertility. This paper is a preliminary report on the results of a survey of the soils in the Port Moresby area. The survey was conducted by the Department of Agriculture at the University of Papua New Guinea. The soils are not used extensively by native people, when done, however a shifting type cultivation is used.

MATERIALS AND METHODS

The soil was a black clay of the Jackson family (Mabbutt et al. 1960). The profile was:

Horizon	Depth (cm)	Description
A	0-50	Black (M/O) hard fine-grained silty clay with occasional small pieces of limestone concretions, sticky and plastic when wet, pH 6.5.
B	50-100	Black (M/O) clay, hard, massive, sticky, plastic when wet, pH 6.5.
C	100-150	Black (M/O) clay, hard, massive, sticky, plastic when wet, pH 6.5.

Chemical analyses and chemical data are given in Table 1. The soil was analysed at the Department of Chemistry, University of Papua New Guinea.