EFFECT OF ARTIFICIAL DEFOLIATION ON COCONUT YIELDS IN PAPUA NEW GUINEA

Peter Bailey*, Dermot O'Sullivan†, and Christopher Perry‡

ABSTRACT

Damage caused by defoliating insects to coconut palms was simulated by removal of 0, 10, 20, 30, 40, 50, 60 and 70 per cent of the frond area; each treatment was replicated 10 times. This level of defoliation was maintained for 12 months by removal of leaf area of new fronds to the predetermined level.

Yields of nuts produced after 9 months defoliation decreased linearly with increasing defoliation. The causes of the reduction in total nuts were an accelerated shedding of nuts already on the tree at the commencement of defoliation, and premature nut fall during growth of a new crop.

After 9 months defoliation, the number of fronds produced by the 70% treatment palms was significantly reduced. There was no evidence of compensatory frond growth in any treatment.

Significant yield differences were detected in the 50% and 60% treatment palms until 5 months after defoliation ceased, and in the 70% treatment palms 17 months after cessation of defoliation.

It is concluded that defoliation above 40% has long term effects on the health of the tree.

INTRODUCTION

Coconut palms in most of Papua New Guinea are subjected to periodic attack from insects which reduce their photosynthetic area. The most important of these are coconut treehoppers, *Segestidea* spp., which chew the fronds. Although these insects are thought to reduce coconut yield, a damage versus yield relationship suitable for use in pest population studies is wanting.

In a study of similated defoliation, Krishna Marar and Padmanabhan (1970) found that regular cutting of old fronds from trees during a four year trial did not affect yield. However, "drastic" pruning of fronds throughout a three year trial reduced yield; the palms recovered when the treatment was discontinued.

The aim of the present study was to relate loss of frond area to yield. This study is preliminary to a later study of populations of *Segestidea* spp. in Papua New Guinea in which pest density will be related to loss of frond area.

The method used in this study was to remove part of the frond area by cutting. There are two main problems in extrapolating from an experiment in which part of the frond area is removed artificially, to a field pest situation: first, severity of defoliation in the field may change from month to month, reflecting the dynamic nature of the pest population and second, the damage simulated by cutting may not have the same physiological effect on the palm as the chewing of insects. However, until a pest density-damage-yield relationship is painstakingly established under conditions of field attack, it is hoped that the data presented below will enable the establishment of an economic threshold (in the sense of Stern, 1973) which will be useful in estimating crop damage.

* Formerly Entomologist, Department of Primary Industry. Present address: South Australian Department of Agriculture and Fisheries, Research Centre, Loxton, South Australia, Australia, 5333.

† Formerly Entomologist, Department of Primary Industry. Present address: P.O. Box 965, Bundaberg, Queensland 4670.

‡ Entomologist, Lowlands Agricultural Experiment Station, Keravat.

METHODS

The experiment was done on Pellavarua plantation, near Rabaul (4°21'S. 152°2'E.) on New Britain. At the start of the experiment, the palms were 6 years old, and bearing well. The crowns of the palms were low enough to enable the fronds to be cut from the ground, using curved knives mounted on bamboo poles. The spadices and nuts could be easily counted with the aid of binoculars.

Eight treatments, each replicated 10 times, were allocated at random to a block of 80 palms. The treatments were 0, 10, 20, 30, 40, 50, 60 and 70% removal of the total frond area. At the beginning of the experiment, the total number of fronds on each tree were counted, and the pinnae from the number of fronds corresponding to the predetermined treatment level were removed, starting from the youngest opened frond. The rachis was not cut off. Where a fraction of a frond was to be removed, the fraction was estimated by dividing the frond area on each side of the rachis into equal fifths. Thus, for example, on a palm which had initially 27 opened fronds, from which 40% of the frond area was to be removed, the pinnae were completely cut from 10 fronds. From the eleventh, the pinnae were completely cut from one side, and then from three fifths of the length of the other side, starting from the axillary end.

For each of twelve months following this initial defoliation all newly-opened fronds were subjected to the predetermined level of defoliation. Thus, for example, if a 50% treatment palm produced one new frond during a month, the pinnae were cut from one side of this frond.

Prior to defoliation, pre-treatment counts of total nuts, spadices and fronds were made. Then, the youngest spadix on each tree was marked so that counts could be made of the number of nuts which were on the tree at the start of the experiment. In addition, the number of nuts on the marked spadices were counted. After twelve months, all the marked spadices were either lowermost, or had fallen off. Total numbers of fronds and spadices were counted.

Defoliation was stopped after 12 months but counts of "large " nuts were continued for a further 22 months. "Large" nuts were those defined as being the size of a cricket ball (about 7cm diameter) or larger.

RESULTS

All the results are presented as treatment means (10 replicates per treatment) adjusted for covariation with pre-treatment counts. Analyses of variance were performed on adjusted data, and differences between adjusted treatment means were detected by the least significant difference (L.S.D.) test.

The fate of the cohort of nuts, of a known age, produced on the youngest opened spadix of each palm and marked at the start of defoliation, is shown in *Table 1*. The normal, physiological shedding of a proportion of small nuts was almost completed at the first count, three months after defoliation commenced. Already, the accelerated nutfall is apparent in the 70% treatment. After five months, significant accelerated nutfall is apparent in the 50 to 70% treatments.

Table 1.— Mean number of nuts on marked spadices. Adjustment has been made for covariation with pre-treatment nut count. Means have been rounded to the nearest whole number.

Level of Defoliation %	Pre-treatment Count	Mean No. of Nuts Months since start of treatment 3	5	6	8	9
0	35	8	7	6	6	5
10	47	6	5	5	3	3
20	52	6	5	4	4	4
30	24	5	4	4	4	4
40	36	5	5	4	4	3
50	28	4	3	3	1	1
60	33	5	4	4	3	2
70	37	3	1	1	0	0
L.S.D. = 0.05		2.7	2.2	2.2	2.0	2.1

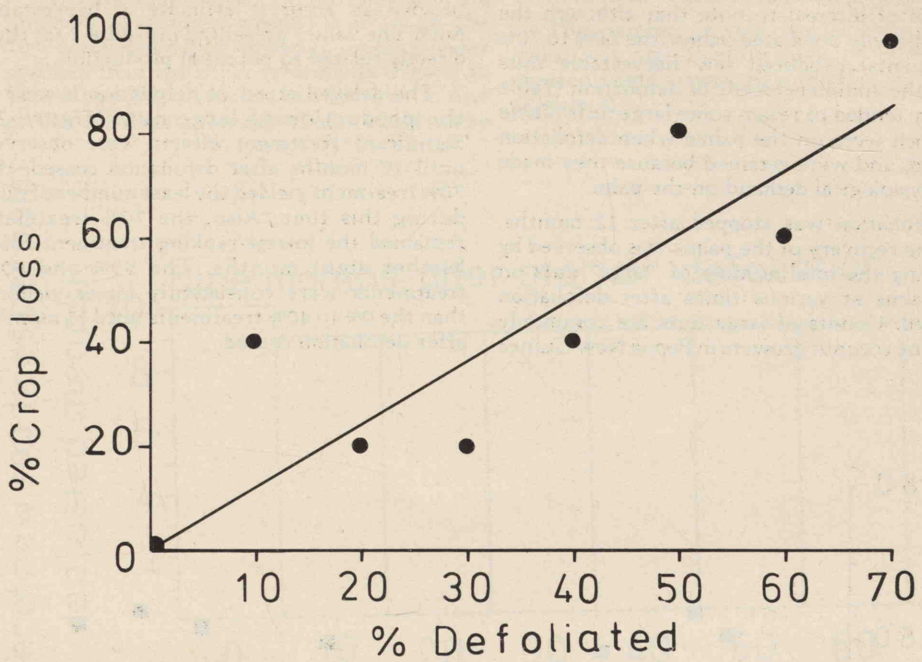

Figure 1.— Relationship between level of defoliation and crop loss after 9 months defoliation. Each point represents the adjusted mean number of mature nuts on the spadix which was youngest on each tree when the experiment started, expressed as a percentage of the control palms.

The reduction in yield is estimated as the difference between the numbers of nuts on the control palms and on the treated palms after nine months (from *Table 1*); these data expressed as percentages are presented as a linear regression of percent defoliation in *Figure 1.* The nut count after nine months is an estimate of the harvestable crop.

Because spadices are produced more or less continuously throughout the year, the nuts on each palm were of different ages when defoliation started. The rates of retention of these nuts are shown in *Table 2.* The trends are similar to those shown in *Table 1;* fewer nuts were retained by the defoliated palms, and fewer nuts were retained as defoliation increased. After nine months, the 40% to 70% palms retained significantly fewer nuts than the control palms.

Table 2.— Mean number of nuts on palms at beginning of defoliation which were subsequently retained. Adjustment has been made for pre-treatment nut count. Means have been rounded to the nearest whole number.

Level of Defoliation %	Pre-treatment Count	Mean No. of Nuts Months since start of treatment 3	5	6	8	9
0	131	71	59	45	40	34
10	181	65	59	41	31	22
20	186	70	51	39	32	24
30	119	66	41	33	28	26
40	152	65	38	30	23	17
50	124	61	30	21	14	9
60	194	67	37	28	19	14
70	149	41	16	5	2	1
L.S.D. = 0.05		N.S.	17	15	12	12

It is of interest to note that although the more heavily defoliated palms (the 50% to 70% treatments) produced few harvestable nuts after the commencement of defoliation (*Table 1*) they tended to retain some large nuts (*Table 2*) which were on the palms when defoliation started, and were retained because they made no physiological demand on the palm.

Defoliation was stopped after 12 months, and the recovery of the palms was observed by counting the total number of "large" nuts on the palms at various times after defoliation stopped. Counts of large nuts are commonly made by coconut growers in Papua New Guinea to give an accurate estimate of harvestable nuts. The values presented in *Figure 2* are thus directly related to potential production.

The delayed effect of defoliation is seen in the production of large nuts (*Figure 2*). Significant treatment effects were observed until 17 months after defoliation ceased; the 70% treatment yielded the least number of nuts during this time. Also, the 70% treatment remained the lowest-ranking treatment for a further eight months. The 50% and 60% treatments were consistently lower yielding than the 0% to 40% treatments until 11 months after defoliation ceased.

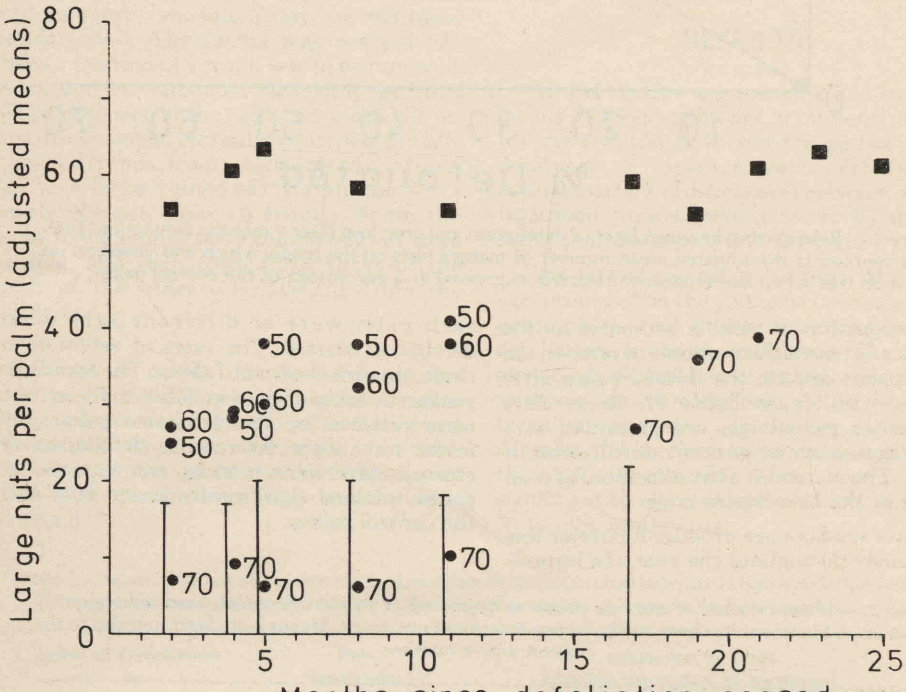

Figure 2.— Recovery of nut production after cessation of defoliation. Solid squares are the means of treatments which do not differ significantly from controls. Solid circles represent treatment means which differ significantly from controls: numbers indicate percent defoliation. At 19 and 21 months after defoliation, the 70% treatment did not differ significantly from controls, but the means are included separately to show the tendency for these palms to produce low yields.

Vertical bars span 5% L.S.D. probability levels.

There were no significant differences in the numbers of spadices produced although the 70% defoliated palms tended to produce fewer spadices than the other treatments (*Figure 3*). Thus the significant reduction in nut production during this experiment could not be attributed to reduced production of spadices.

The number of new fronds produced per palm was significantly reduced in the 70% treated palms, compared with other treatments (*Figure 4*).

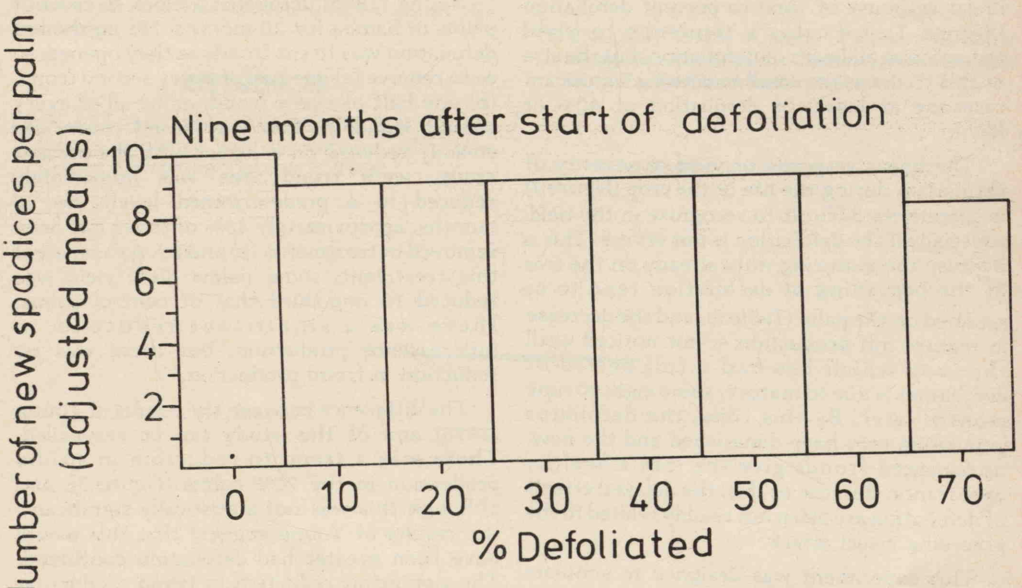

Figure 3.— Mean number of new spadices produced since the start of defoliation.

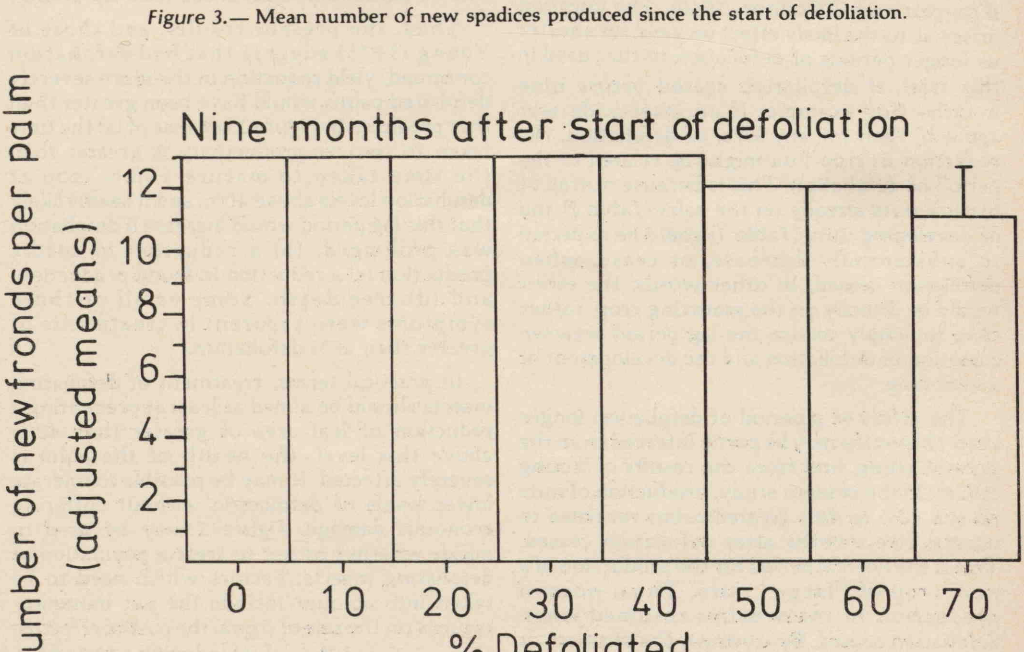

Figure 4.— Mean number of new fronds produced since the start of defoliation. Vertical bar spans the 0.05 L.S.D. value.

DISCUSSION

In terms of the design of this experiment, statistically significant treatment effects could only be demonstrated above the 40% level of defoliation (*Table 1* and *Figure 2*). However, the linear response of yield to percent defoliation (*Figure 1*) indicates a tendency to yield reduction at all levels of defoliation, but the size of this trial was too small to detect a significant response at levels of defoliation of 40% or lower.

The linear response of yield to severity of defoliation during the life of the crop (*Figure 1*) is sometimes difficult to recognise in the field, especially if the defoliation is not severe. This is because the maturing nuts already on the tree at the beginning of defoliation tend to be retained on the palm (*Table 2*), and the decrease in mature nut production is not noticed until the crop which has had a full period of defoliation is due to mature, some eight to nine months later. By this time, the defoliator population may have diminished and the new, undamaged fronds give the tree a healthy appearance. Because of this, the delayed effects of defoliation are often not readily related to the preceding insect attack.

This experiment was designed to simulate the attack of a single generation of treehoppers, which may be of nine to 12 months' duration (Froggatt and O'Connor, 1940). The question arises as to the likely effect on yield for shorter or longer periods of defoliation to that used in this trial. If defoliation ceased before nine months (for example, if an insecticide was applied), then for any level of defoliation, the reduction in crop loss might be related to the period of defoliation. This is because nutfall of mature nuts already on the palm (*Table 2*) and of developing nuts (*Table 1*) could be expected to substantially decrease, or cease, when defoliation ceased. In other words, the effect would be directly on the maturing crop, rather than to simply reduce the lag period between cessation of defoliation and the development of a new crop.

The effect of a period of defoliation longer than 12 months may be partly inferred from the present study, and from the results of Young (1975). In the present study, production of nuts on the 10% to 40% treated palms returned to normal five months after defoliation ceased. This is the normal period for the production of a new crop of "large" nuts. Thus, normal production in these palms resumed when defoliation ceased. By contrast, the recovery of the 50% to 70% palms was longer than the maturation period of a normal crop. It thus appears that the 50% to 70% treatments affected the health of the palms much more severely than the other treatments, and it is possible that if defoliation were prolonged, the lag in recovery might be proportionately longer.

Young (1975) defoliated a block of coconut palms in Samoa for 20 months. His method of defoliation was to cut fronds as they opened, so as to remove (a) one half of every second frond, (b) one half of every frond, or (c) all of every second frond. In this way frond cover was steadily reduced (in contrast with the present study, were frond area was immediately reduced to a predetermined level). By 20 months, approximately 45% of cover had been removed in treatments (b) and (c). As a result of this treatment, some palms died, yield was reduced to one-third that of control palms, there was a significant reduction in inflorescence production, but there was no reduction in frond production.

The difference between the results of Young (1975) and of this study can be reconciled. There was a trend to reduction in spadix production in the 70% palms (*Figure 3*), and although this was not statistically significant, the results of Young suggest that this would have been greater had defoliation continued. The significant reduction in frond production found in the present study occurred at a higher level of defoliation than those used by Young.

Thus, the present results, and those of Young (1975) suggest that had defoliation continued, yield reduction in the more severely defoliated palms would have been greater than that predicted in *Figure 1* because of (a) the time taken to recover productivity is greater than the time taken to mature a new crop at defoliation levels above 40%, and it seems likely that this lag period would increase if defoliation was prolonged, (b) a reduction in spadix production (c) a reduction in frond production, and (d) tree death. Some or all of these symptoms were apparent in treatments of greater than 40% defoliation.

In practical terms, treatment of defoliating insects should be aimed at least at preventing a reduction of leaf area of greater than 40%; above this level, the health of the palm is severely affected. It may be possible to tolerate lower levels of defoliation without suffering economic damage. *Figure 1* may be used to decide whether or not to treat a population of defoliating insects. Factors which need to be taken into account include the net monetary returns on the sale of copra, the cost of effective treatment, and the risk of inducing a resurgent pest population by wrong treatment leading to damage of greater intensity.

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