EFFECTS OF PESTS AND DISEASES ON THE YIELD AND QUALITY OF TOMATOES IN THE PORT MORESBY AREA, PAPUA NEW GUINEA

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ABSTRACT

Studies with tomato variety 'Red Cloud' at Port Moresby showed that the greatest cause of crop loss was fruit damage by the Tomato Caterpillar Heliothis armigera *and, to a lesser extent, the Cluster Caterpillar* Spodoptera litura. *Weekly spraying with 2 g/litre of the insecticide 'Septene 80' (Carbaryl) reduced the numbers of caterpillars and, consequently, the proportion of fruit insect-damaged. Insecticide effectiveness was greater during the dry season when insect damage was reduced from 71.5% to 25.6% of all fruit. Application of 1.5 g/litre of fungicide 'Dithane M-45' (Mancozeb) did not affect the proportion of fruit damaged by* Phytophthora nicotianae *and* Sclerotium rolfsii *rots, which together caused a crop loss of 1.6%. The physiological disorders Blossom End Rot and Growth Cracking occurred on a total of 5.2% of fruit. Flood irrigation during the dry season trial apparently reduced the incidence of Blossom End Rot. Under most favourable conditions a marketable fruit yield potential of 41 t/ha was realised.*

INTRODUCTION

In Papua New Guinea the tomato *Lycopersicon esculentum* Mill. is grown as a minor crop in subsistence gardens, while intensive market gardening techniques are being used increasingly in many areas, including Port Moresby. All stages in the development of tomato plants and fruit are susceptible to attack by a variety of pests and diseases. Successful commercial production is usually only possible if these are controlled.

In Papua New Guinea, some insect pests of tomato were reported by Dumbleton (1954), Barrett (1967) and Anon. (1970 and 1971) while Shaw (1963) listed several tomato diseases caused by fungi, bacteria, nematodes and, possibly, viruses.

Fruit losses averaging 45% of total yield have been reported for experiments in the Port Moresby area (Dodd 1976 and 1977; Kesavan 1977). This paper reports the impact of pests diseases and disorders on fruit yield and quality, and the effectiveness of a fungicide and an insecticide, separately and in combination.

MATERIALS AND METHODS

A determinate variety 'Red Cloud' of proven merit in yield trials in the Port Moresby area (Dodd 1977; Kesavan 1977) was used in field trials involving four treatments: Fungicide (F), Insecticide (I), Fungicide with Insecticide (F + I) and Control. The experiment was replicated five times at each of the two planting dates, 7/4/76 (wet season) and 9/7/76 (dry season). The dry season experimental site was lightly infested with Root Knot Nematode, *Meloidogyne incognita* Chitwood: its effects on yield during that trial are reported separately (Dodd 1979). Insecticide 'Septene 80' (carbaryl) and fungicide 'Dithane M-45' (mancozeb) were used at the rates of 2 g/litre and 1.5 g/litre respectively, with Yates' 'Sprayfix' as wetting agent at 0.7 ml/litre. Spray was

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applied using a manually pumped knapsack sprayer.

Individual plots consisted of ridges 1 m apart along which unstaked plants were spaced at 50 cm intervals (20,000 plants per hectare). In the wet season trial there were five rows of seven plants in each plot (giving an inner plot of three rows of five) while in the dry season there were four rows of nine (giving an inner plot of two rows of seven). Plots were separated by 2 m wide pathways. Plants were mulched with dry grass and fertilized with a 50 g per plant basal dressing of B.A.S.F. 'Nitrophoska Special Blue' at transplanting with a side-dressing of the same quantity at the onset of flowering.

Spray application began 6 days after transplanting in the wet season trial and after 15 days in the dry season trial, and was repeated at weekly intervals. The final application was made two days after the first harvest in the wet season trial and one day after the third harvest of the dry season. Contamination by spray drift was countered by using guard rows and inter-plot pathways, and by spraying only in the relatively windless mornings.

Plants were regularly inspected for signs of fungal infection. Counts were made of the number of larvae of *Heliothis armigera* Hb. and *Spodoptera litura* F. on 3 plants of each plot before flowering had started.

Records were taken from ten experimental plants chosen at random from the inner plot bordered by the guard row. At each harvest all undamaged, ripe and green-mature fruit were removed, together with any that were damaged by fungi, insects, Blossom End Rot and Growth Cracks. Weights and numbers of fruit in each category were recorded. Three harvests were taken from the wet season trial. During the dry season trial six harvests were made although results of only the first three were subjected to statistical analysis. Results from the two trials were analysed together using combined analysis of variance as described in Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

The most important factor affecting the quality and yield of marketable fruit was the damage caused by caterpillars of *H. armigera* and *S. litura*, especially the former. Application of 'Septene 80' had a marked effect on the number found on plants when counts of larvae were made. None was found on plots receiving insecticide (I and F + I) in the wet season, although small numbers were counted on those receiving the combined fungicide and insecticide (F + I) spray in the dry season *(Table 1)*.

Insecticide application significantly reduced the proportion of total fruit yield damaged by caterpillars and, conversely, resulted in a higher percentage of undamaged and thus marketable fruit *(Table 2)*.

The effects of insecticide were greater during the dry season when spray deposits persisted on plants. In the wet season, rain probably removed some of the applied spray despite the use of a sticking agent. In both seasons the level of insect damage to fruit in the +I treatments increased after spraying had ceased, and in the dry season reached the value for -I treatments *(Figure 1C and 1D)*. The increase was accelerated by heavy rainfall a few days after the final spraying in both seasons. The use of ditch irrigation during the dry season prevented spray removal which would have occurred with overhead sprinkling. Control in plots receiving insecticide (I and F + I) was, however, far from complete, as shown by the relatively high levels of fruit damage *(Table 2)* and the presence of caterpillars on (F + I) plots *(Table 1)*. This was due partly to incomplete penetration of insecticide into the dense foliage produced by 'Red Cloud', while a further cause was rapid crop growth producing unprotected shoots and fruit bunches which were vulnerable to caterpillar attack between spray applications. Improved spray coverage would result from staking although high costs of labour may render this uneconomical. In view of the significant reduction in caterpillar numbers and insect damage following application of 'Septene 80', it would be desirable to test a variety of spraying schedules and insecticides to find an effective minimum and economical application for intensive tomato production.

Fruit size, as indicated by the mean weight of individual undamaged fruit, responded in a complex manner. In

Table 1. — Effects of treatment on caterpillar numbers, fruit rot percentage and total weight and number of fruit per plant

Treatment	Mean number of *H. armigera* & *S. litura* larvae per plant: WET SEASON	DRY SEASON	Percentage of total fruit number affected by *P. nicotianae* and *S. rolfsii* rot	Total weight of fruit per plant (grams)	Total number of fruit per plant
Control	1.3 b*	2.3 b, c	0.8 a	759.7 a, b	12.4 a, b
Fungicide alone	2.4 c	1.4 b	0.3 a	688.3 a	10.8 a
Insecticide alone	0.0 a	0.0 a	2.8 b	881.6 b	13.0 b
Fungicide & Insecticide combined	0.0 a	0.5 a	2.5 b	1244.9 c	16.1 c
Mean	0.9	1.1	1.6	893.6	13.1

* Values indicated with the same letter within a column do not differ significantly at P< 0.05.

Table 2. — Effects of season and insecticide on percentages of total fruit number undamaged and insect damaged, and on mean size of undamaged fruit. Treatments receiving (+I) or lacking (−I) insecticide 'Septene 80'

Treatment and Season	Percentage of undamaged fruit	Percentage of insect-damaged fruit	Mean size of undamaged fruit (grams)
−I, Wet Season	19.8 a*	67.4 c	50.6 a
+I, Wet Season	45.2 b	39.8 b	57.5 b
−I, Dry Season	27.1 a	71.5 c	100.6 c
+I, Dry Season	69.5 c	25.6 a	96.3 c
Mean	40.4	51.1	76.3

* Values indicated with the same letter within a column do not differ significantly at P< 0.05.

general, fruit from +F plots (mean weight = 81.2 g) were significantly larger than those from -F plots (71.3 g), while those produced in the dry season trial were much larger than those of the wet season *(Table 2)*. In both trials, the largest fruit were those from the first two harvests *(Figure 1A)*. The greater fruit size in the dry season trial may have been a response to the improved nitrogen status of the soil of the planting site following winged bean cultivation there.

Fungicide and insecticide application affected other variables of fruit yield, quality and quantity in addition to those directly related to caterpillar damage. Total yield, as measured by both total weight and total number of fruit per plant, was significantly increased when the combined (F + I) spray was applied, although the application of fungicide and insecticide separately had no significant effect *(Figure 1B; Table 1)*. Considering results of the dry season trial alone, total yield of the (F + I) treatments after the final (6th) harvest was 3014 g/plant, equivalent to 60 t/ha, of which 68.3% was undamaged giving marketable yields of 2059 g/plant or 41 t/ha *(Figure 1B)*.

There is no obvious explanation for the greatly increased yield of the (F + I) treatments *(Table 1; Figure 1B)*. There may have been a synergistic effect between fungicide and insecticide, in addition to which 'Dithane M-45'* may have been a source of the nutrients Zn, Mn and S, which could have raised yield, as in the case of certain Zn-containing fungicides which increased potato yields by improving crop nutrition as well as by reducing disease (Callbeck 1954; Hoyman 1949). Nutrients derived this way may also have resulted in the larger fruit of the +F treatments.

The only fungus diseases encountered were the fruit rots caused by *Phytophthora nicotianae* B. de Haan var. *nicotianae* (D.P.I. accession numbers PNG 9237a and IMI 183052a) and *Sclerotium rolfsii* Sacc.. Since it was not possible to differentiate between the two pathogens at harvest, all fruit showing fruit rot symptoms were pooled when the number affected were counted. Fungicide application did not affect the frequency of fruit rot, due possibly to the low incidence of the pathogens, although rot was significantly greater amongst +I treatments *(Table 1)*. Overall, 1.6% of the total fruit number was affected, although the wet season mean of 2.4%, which was significantly higher than the dry season value of 0.7%, was probably related to continual high levels of soil moisture during most of that season and this would have favoured activity of the pathogens. Staking plants to prevent soil contact by fruit would control these diseases but would probably not be economically worthwhile in view of the low level of crop loss caused by fruit rot.

* 'Dithane M-45' = A combination of the Zinc and Manganese radicals of ethylene -1, 2- bisdithiocarbamate.

Figure 1. — Fruit and rainfall measurements for trials in 1976 wet season (left) and dry season (right).

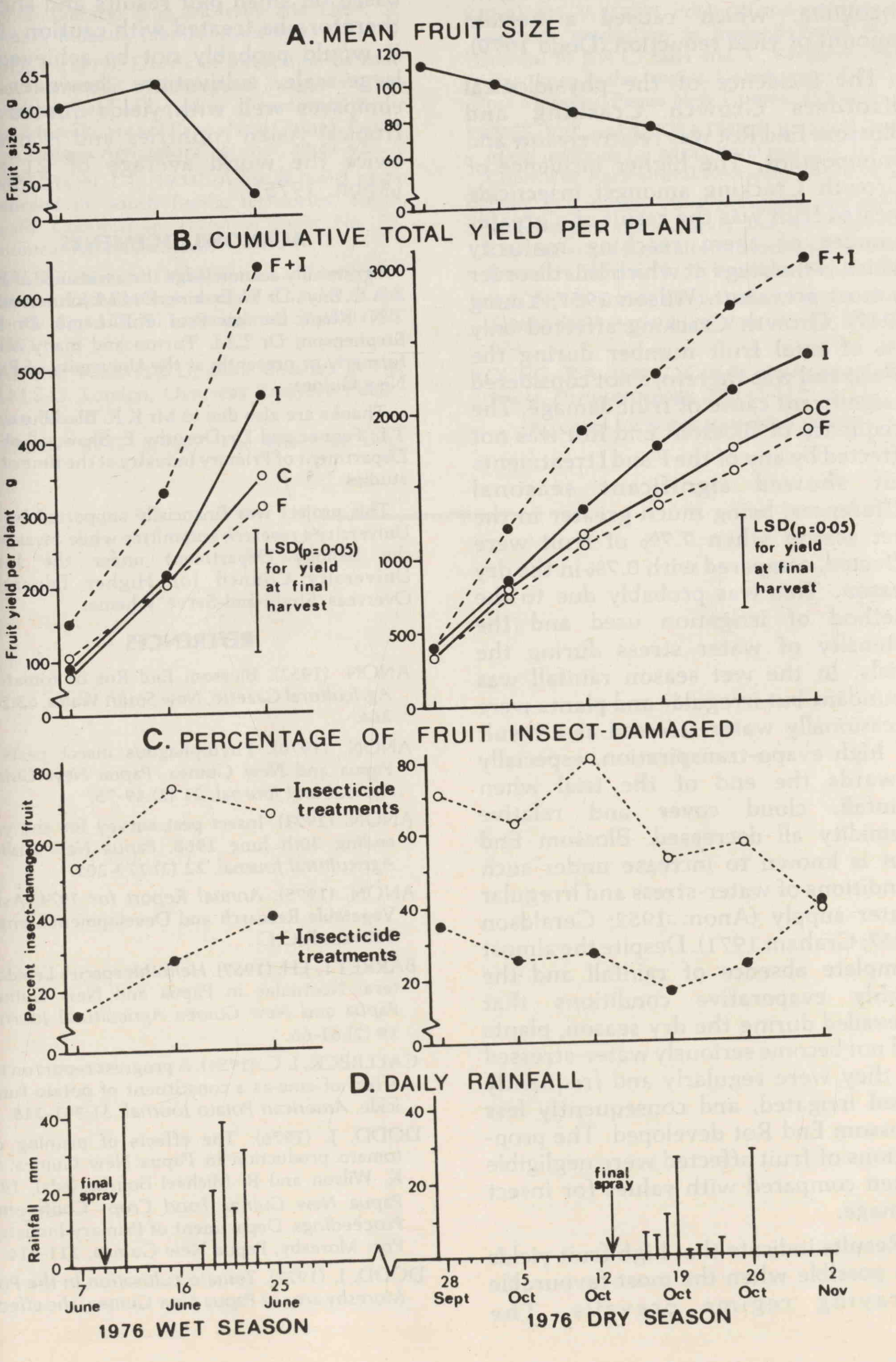
A. Mean size of undamaged fruit, measured as fruit weight; average of all treatments.

B. Cumulative total yield of fruit per plant for different spraying treatments: C = unsprayed control; F = fungicide ('Dithane M-45') alone; I = insecticide ('Septene 80') alone; F + I = fungicide and insecticide together.

C. Percentage of insect-damaged fruit from treatments receiving insecticide (I & F + I) and receiving none (C & F).

D. Date of final spray application, and daily rainfall at experimental site during harvest period.

Figure 1: —See opposite page for caption



None of the dry season spraying treatments affected the level of infestation by Root Knot Nematode, *M. incognita*, which caused a certain amount of yield reduction (Dodd 1979).

The incidence of the physiological disorders Growth Cracking and Blossom End Rot was relatively low and unimportant. The higher incidence of Growth Cracking amongst insecticide treated fruit was the result of a greater number of them reaching maturity which is the stage at which this disorder is most prevalent (Wilson 1957; Young 1947). Growth Cracking affected only 1% of total fruit number during the trials, and was therefore not considered a significant cause of fruit damage. The frequency of Blossom End Rot was not affected by any of the F and I treatments but showed significant seasonal differences, being much greater in the wet season when 7.7% of fruit were affected, compared with 0.7% in the dry season. This was probably due to the method of irrigation used and the intensity of water stress during the trials. In the wet season rainfall was abundant but irregular and plants were occasionally water-stressed as a result of high evapo-transpiration, especially towards the end of the trial when rainfall, cloud cover and relative humidity all decreased. Blossom End Rot is known to increase under such conditions of water-stress and irregular water supply (Anon. 1952; Geraldson 1957; Graham 1971). Despite the almost complete absence of rainfall and the highly evaporative conditions that prevailed during the dry season, plants did not become seriously water-stressed as they were regularly and frequently flood irrigated, and consequently less Blossom End Rot developed. The proportions of fruit affected were negligible when compared with values for insect damage.

Results indicate that high fruit yields are possible when the most favourable spraying regime prevails. The marketable yield of about 40 t/ha for the (F + I) treatments in the dry season was based on small plot results and should therefore be treated with caution since it would probably not be achieved in large-scale cultivation; however, it compares well with yields quoted for tropical Asian countries and is nearly twice the world average of 21 t/ha (Anon. 1975).

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