CONTROL OF TARO LEAF BLIGHT USING METALAXYL: EFFECT OF DOSE RATE AND APPLICATION FREQUENCY

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ABSTRACT

*Metalaxyl (as Ridomil plus 72WP) was used to control leaf blight (*Phytophthora colocasiae *Racib.) of taro (*Colocasia esculenta *(L.) Schott) using a knapsack sprayer. A quadratic dosage-response curve is suggested. The technical optimum response occurs at 0.2 per cent Ridomil plus, using a fortnightly spray regimen. Five applications of 0.3 per cent Ridomil plus, at 3-weekly intervals during the middle of the growing period, can more than double the yield. The responses of yield to dose rate and application frequency are interpreted in terms of (1) the effect of Ridomil plus on the number of leaves per plant, (2) the proportion of plants exhibiting symptoms of blight, and (3) a phytotoxic effect.*

INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott) is an important staple subsistence food crop in many lowland areas of Papua New Guinea. Taro leaf blight (TLB), caused by the fungus *Phytophthora colocasiae* Racib., is one of the most serious of the diseases of taro in Papua New Guinea (Cox and Kasimani 1990).

Previous work at the Lowlands Agricultural Experiment Station (LAES) in East New Britain (Cox and Kasimani 1988) has shown clearly that TLB can be effectively controlled by fortnightly sprays of 0.3 per cent Ridomil plus 72WP (12 per cent active ingredient metalaxyl, 60 per cent active ingredient copper; Ciba-Geigy AG). We used this dose rate in our initial experiment because it was the same as that recommended in Papua New Guinea for controlling black pod in cocoa which is caused by a similar organism, *Phytophthora palmivora*. In this paper, we describe the effect of varying (1) the dose rate, and (2) the application frequency of Ridomil plus.

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MATERIALS AND METHODS

Two field plot experiments were carried out at LAES. Setts of the taro cultivar, K264, were planted at 0.8 m x 0.8 m spacing in a randomized complete block design with five replications of four treatments (30 plants per plot). Growth and yield data were recorded on the central 12 plants of each plot. An additional guard row of *Xanthosoma sagittifolium*, which is not affected by *P. colocasiae*, was used to separate the plots.

The progress of the disease was followed at 3-weekly intervals by (1) counting the number of leaves on the main stem, and (2) noting the presence or absence of leaf blight lesions on each plant.

Experiment 1: effect of dose rate

All plants in all plots were inoculated by spraying with a zoospore suspension of *P. colocasiae* at 36 days after planting (DAP). Metalaxyl (as Ridomil plus 72WP) was applied at three dose rates: 0.1, 0.2 and 0.3 per cent product (0.15, 0.30 and 0.45 kg per hectare active ingredient metalaxyl). The fourth treatment was an unsprayed control. Cittowett spreader/sticker (BASF) was added to the tank mixture at 3 ml per 12 litres. All sprays were applied using a hand-pumped knapsack sprayer with a fine nozzle. The taro was sprayed at 2-weekly intervals starting at 38 DAP. The plants were scored starting at 35 DAP. The main corms were harvested at 246 DAP.

Experiment 2: effect of application frequency

All plants were inoculated by spraying with a zoospore suspension of *P. colocasiae* at 41 DAP. The treatment plots were sprayed with 0.3 per cent Ridomil plus 72WP using a knapsack sprayer with a fine nozzle. Cittowett spreader/sticker (BASF) was added to the tank mixture at 3 ml per 12 litres. Treatment A was sprayed twice (at 49 and 56 DAP); treatment B was sprayed 5 times (49, 70, 92, 112 and 134 DAP); treatment C was sprayed 7 times (49, 63, 77, 92, 105, 119 and 134 DAP); D plots were not sprayed (untreated control). The plants were scored starting at 48 DAP and the main corms were harvested at 259 DAP.

Partial control of taro beetle (*Papuana* sp.) was achieved using three applications of Lindane granules (6 per cent hexachlorocyclohexane, HCH; 1 kg active ingredient per hectare) at planting, 41 DAP and 134 DAP. A top-dressing of nitrogen (225 kg N per hectare as urea) was applied at 58 DAP.

RESULTS

Experiment 1

An analysis of variance (ANOVA) of the harvest data demonstrated a significant effect of treatment with Ridomil plus ($P < 0.001$) but failed to distinguish between the different dose rates ($P > 0.05$) (see Table 1). However, if the rate effect is decomposed into linear and quadratic components, both are significant ($P < 0.001$). The data suggest the existence of a quadratic dosage-response curve.

This relationship was explored using multiple regression analysis. The mean corm weight (Y) was related to the dose rate of Ridomil plus (X) by the second order polynomial:–

$$Y = 309 + 4105\,X - 10525\,X^2, \quad R^2 = 0.98$$

S.E.: (26) (417) (1330)

The increase in corm weight following application of Ridomil plus to diseased plants was associated with an increase in leaf number (see Table 2). Although plots treated with 0.2 per cent Ridomil plus had slightly greater mean cumulative leaf number per plant throughout the later stages of crop growth (after the disease had become established in the crop), the differences between the Ridomil treatments were not significant ($P > 0.05$). The reduced efficacy of 0.1 per cent Ridomil compared with the higher dose rates is shown by the greater proportion of infected plants (see Table 3).

Experiment 2

This experiment again demonstrated the significant effect ($P < 0.05$) on the yield of taro of Ridomil plus treatment in the presence of leaf blight (see Table 4). The relationship was explored using multiple regression analysis.

Table 1.–**Mean corm weight of taro (n=60) following application of Ridomil plus 72WP at different dose rates at fortnightly intervals (Experiment 1).**

Treatment	Mean Corm Weight (g)
unsprayed control	303
0.1% Ridomil plus	632
0.2% Ridomil plus	691
0.3% Ridomil plus	599
S.E.D.	46.8

Table 2.–**Effect of the application rate of Ridomil plus (per cent) on the mean number of leaves per plant (n=60) at different times during the crop cycle (Experiment 1).**

	Ridomil plus dose rate				
DAP*	0	0.1%	0.2%	0.3%	LSD
35	2.3	2.7	2.8	2.7	0.46
56	3.2	4.3	3.9	3.8	0.61
77	3.1	4.4	4.1	4.2	0.76
98	2.5	4.7	4.7	4.6	0.61
140	3.3	4.0	4.2	4.1	0.27
161	2.2	4.2	4.6	4.4	0.60
182	2.9	3.4	3.6	3.5	0.51
203	2.7	3.4	3.4	3.1	0.70

* Days after planting
LSD = Least Significant Difference (P = 0.01)

Table 3.–**Effect of the application rate of Ridomil plus on the percentage of taro plants showing blight symptoms (n=60) at different times during the crop cycle (Experiment 1).**

DAP*	Dose Rate: 0	0.1%	0.2%	0.3%
35	2	7	0	0
56	82	7	2	2
77	100	18	0	0
98	100	37	3	2
140	90	15	0	0
161	100	38	5	0
182	63	25	2	7
203	70	20	0	0
Mean	76	21	2	1

* Days after planting

The mean corm weight (Y) was related to the number of fungicide applications (X) by the third order polynomial:–

$$Y = 269 + 36.4\ X^2 - 4.45\ X^3, \quad R^2 = 0.997$$
$$\text{S.E.:} \quad (15.8) \quad (2.75) \quad (0.387)$$

The exclusion of the linear term from this equation is theoretically justified because of the uneven pesticide cover achieved with the use of only two sprays close together, compared with five or seven equally spaced applications

As in Experiment 1, the increase in mean corm weight following Ridomil plus application to diseased plants is associated with an increase in leaf number (see Table 5), and a reduction in the proportion of plants showing symptoms of leaf blight (see Table 6).

DISCUSSION

These experiments confirm the previous work by Cox and Kasimani (1988) on the effectiveness of Ridomil plus application using a knapsack sprayer for the control of taro leaf blight. As they suggested, it appears that the dose rate of Ridomil plus can be reduced from 0.3 per cent to 0.2 per cent (using a fortnightly spray regimen) whilst maintaining effective control of the disease. The data presented here support the theoretical notion of a quadratic dosage response curve which reflects diminishing marginal returns to increasing dose rate, with negative marginal returns above a dose rate of about 0.2 per cent. The technical optimum dose rate, obtained by differentiation of the regression equation, is close to 0.2 per cent (0.195 per cent).

Although the overall response to Ridomil plus application is associated with an increase in leaf number per plant, in accordance with our present understanding of the principal effect of leaf blight on the taro plant (Cox and Kasimani 1990), this does not account for the distinct curvature of the response surface in the neighbourhood of the technical optimum. The lower yield of plants receiving 0.1 per cent Ridomil plus can be explained by the greater proportion exhibiting symptoms of leaf blight. Although sufficient to prevent loss of leaf number, the lower dose rate is not sufficient to prevent infection and the concomitant reduction in the effective area of the leaves that remain. The reduction in yield to the right of the technical optimum, although again associated with a non-significant reduction in leaf number per plant, may be evidence of a direct phytotoxic effect.

Thus using Ridomil plus at 0.2 per cent is better than 0.3 per cent (lower direct costs, greater yield response) using a 2-weekly spray schedule. Fine tuning of the dose rate between 0.1 per cent and 0.2 per cent does not appear to be feasible given the variation in potential yield, levels of leaf blight and uniformity of spray cover which might be expected under normal field conditions. Dose rates below 0.1 per cent are unlikely to work effectively because of the substantial reservoir of inoculum remaining even using 0.1 per cent Ridomil plus.

It is clear from Experiment 2 that, in the presence of leaf blight, the mean corm weight of taro can be doubled by as few as five applications of 0.3 per cent Ridomil plus 72WP. The timing of these applications is important. The use of only two sprays was partly successful in that a low level of disease was achieved for a short time: 36 days after the second spray, there was still no significant reduction in leaf number per plant compared with plots receiving additional spray applications (treatments B and C), although the percentage of plants exhibiting symp-

Table 4.–**Effect of the number of applications of 0.3 per cent Ridomil plus 72WP on the mean corm weight (n=60) of taro (Experiment 2).**

Number of sprays	Mean Corm Weight (g)
0	260
2	391
5	618
7	528
L.S.D. (P=0.05)	214

Table 5.–**Mean number of leaves per plant (n=60) at different times during the crop cycle in relation to the number of applied sprays of 0.3 per cent Ridomil plus 72WP (Experiment 2).**

DAP*	Number of sprays				LSD (P = 0.01)
	0	2	5	7	
48	4.0	4.3	4.0	3.9	1.3
69	2.7	3.5	3.4	3.3	0.36
92	2.1	3.3	3.6	3.7	0.58
111	2.3	2.6	3.2	3.4	0.63
134	2.5	3.1	4.2	4.1	0.82
175	2.7	2.7	3.3	3.3	0.60
195	2.3	2.3	2.1	2.2	0.74
217	2.4	2.4	2.2	2.4	0.32

* Days after planting

Table 6.–**Effect of different numbers of Ridomil plus applications on the percentage of taro plants exhibiting blight symptoms (n=60) at different times during the crop cycle (Experiment 2).**

DAP*	Number of sprays			
	0	2	5	7
48	60	80	83	85
69	90	8	33	10
92	93	65	40	5
111	7	40	10	0
134	93	95	0	0
175	92	95	67	50
195	85	85	75	62
217	85	72	80	70
Mean	84	68	49	35

* Days after planting

toms of leaf blight was much higher. Similarly, the number of leaves per plant following cessation of spraying in B and C plots was still significantly greater than in control plots 41 days later even though by this time (175 DAP) the proportion of plants with blight was increasing rapidly. The protective effect on leaf number lasted for at least 5–6 weeks. It may be longer in large plots where plants are not in the immediate vicinity of a reservoir of inoculum.

The differences between the percentage of infected plants in B and C plots suggest that the disease was more rapidly brought under control using a fortnightly rather than a 3-weekly spray regimen, and it increased more slowly following the withdrawal of pesticide cover. The total amount of Ridomil plus applied to C plots, which received seven sprays, was 40 per cent higher than the amount applied to B plots, which had five sprays.

Differentiation of the regression equation relating yield of taro to the number of spray applications indicated a turning point (the technical optimum) at about 5.5 spray applications. The curvature of the response surface to the left of the technical optimum (i.e. the lower yield of plants receiving two sprays compared with those receiving five) can be interpreted in terms of the effect of blight on leaf number after cessation of spraying. The reduced yield to the right of the optimum (plants receiving seven sprays) may be evidence of a direct phytotoxic effect. There is less disease in these plots as estimated by the percentage of infected plants but this is not translated into an increase in corm weight. This result is analogous to the reduced yield obtained in Experiment 1 using a 0.3 per cent solution when sprays are applied routinely according to a 2-weekly regimen. The existence of this effect also means that previous estimates of the potential yield loss associated with leaf blight (Cox and Kasimani 1988) need to be revised upwards slightly: in these experiments, leaf blight is shown to be capable of causing at least a 58 per cent reduction in taro corm weight.

There appears to be little value in inserting a sixth spray during the hypothetical 3-month critical period for spray application Cox and Kasimani (1988) as the technical optimum lies between five and six sprays, and by six applications the marginal productivity of further sprays is already negative. Also, the application interval has an integer quality: a spray interval which was not a multiple of a week would be hard to implement. Similarly, reduction of the number of sprays to four is probably unwise because (1) use of five applications is to the left of the technical optimum, (2) the third order nature of the response function indicates that the curvature of the response surface is very pronounced in the region between two and five applications, (3) the integer quality of the application interval is removed, and (4) even with five sprays, there is a substantial reservoir of inoculum. However, the equation is based on only four treatments. The interval between two sprays and five sprays is large, and the way in which the two sprays were applied (close together) was different from the way in which the five and seven sprays were applied (equally spaced).

An economic optimum cannot yet be defined for either the number of spray applications to use (i.e. the number which equates marginal revenue with marginal cost), or for the dose rate, because of lack of information about the valuation of subsistence output and the opportunity costs of labour and capital in subsistence production. However, if a farmer wishes to spray his taro crop with Ridomil plus on the basis of his own perception of the potential yield response and his own valuation of inputs and outputs, five applications of a 0.3 per cent solution at 3-weekly intervals during the early-middle part of the growing season, or fortnightly applications of a 0.2 per cent solution, can be suggested in areas where the disease is endemic. It should be noted that late infection, although not contributing substantially to yield reduction, might have other effects: (1) it is suggested by some farmers that leaf blight spoils the eating quality of the corm giving it a "bitter" taste, (2) it may contribute to the development of corm rot either in the ground or in storage, and (3) it means that the planting setts will be carrying over inoculum to infect the succeeding crop. These may justify additional measures for the management of the disease.

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