EFFECT OF TARO LEAF BLIGHT ON LEAF NUMBER

P.G. Cox*† and C. Kasimani*

ABSTRACT

Leaf blight (Phytophthora colocasiae Racib.) of taro (Colocasia esculenta (L.) Schott) causes a reduction in leaf number compared with healthy control plants. The proportional reduction in leaf number provides a partial disease index if the time when the disease becomes established in the crop is fixed. The reduction in leaf number, after equilibration, is directly proportional to the number of leaves on healthy plants, which varies over the crop cycle. This has implications for the design of disease management strategies involving intervention during the growing season.

INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott) is important as a staple subsistence food crop in many of the lowland areas of Papua New Guinea. It is commonly grown in traditional gardens following a long bush fallow (5–25 years) and may be inter-cropped with many other species. Purchased agricultural inputs are rarely used. Leaf blight, caused by the fungus *Phytophthora colocasiae* Racib., is a serious disease of taro in Papua New Guinea, although the annual loss of yield which may be attributed to it is not yet known.

Previous work at the Lowlands Agricultural Experiment Station (LAES) in East New Britain (Cox and Kasimani 1988) has clearly demonstrated that taro leaf blight can be effectively controlled by fortnightly sprays with 0.3 per cent Ridomil plus 72WP (12 per cent active ingredient metalaxyl, 60 per cent active ingredient copper; Ciba-

Geigy AG). The use of Ridomil plus in this way should not be dismissed simply because it is a purchased input. The ability to control taro leaf blight is a useful tool for research purposes: to help identify taro cultivars with differences in resistance to the disease (by being able to grow taro in the presence and absence of leaf blight); and to explore the way in which the yield loss caused by leaf blight is caused (by being able to regulate the amount of the disease in the crop at different stages of crop development).

The measurement of leaf area has been an important aspect of previous work on taro leaf blight (*e.g.* Jackson *et al.* 1980) since the effect of leaf blight on yield has been interpreted in terms of a reduction in leaf area. Chapman (1964) showed that the area of a *Xanthosoma sagittifolium* leaf could be estimated by the relationship:–

$$y = c_1 + c_2 ab^2 \qquad (1)$$

where y = leaf area
a = distance from the sinus to the leaf tip
b = distance from the sinus to the tip of the basal lobes
c_1, c_2 are constants.

---

* Lowlands Agricultural Experiment Station, P.O. Kerevat, East New Britain Province, Papua New Guinea.
† Present address: CSIRO Cotton Research Unit, P.O. Box 59, Narrabri, NSW 2390, Australia.

This method was used by Jackson *et al.* (1980) in their study of the effect of fungicides on the development of leaf blight. It was also used by Caesar (1980) in his study of the growth and development of *Xanthosoma* sp. and *Colocasia* sp. under different light and water conditions. The method is slightly different for *Colocasia esculenta* because the leaf sinus and the point of insertion of the petiole are not coincident. Either may be used as a reference point for leaf measurements. Nevertheless, the equation is dimensionally inconsistent: the left hand side has the dimensions of area (L^2), but the right hand side is a volume (L^3).

Bourke *et al.* (1976) have pointed out that the area of a taro leaf can be estimated from the square of the single linear dimension "a" of equation (1) above, and this procedure has been used by Bourke and Perry (1976) in their study of the influence of sett size on the growth and yield of taro. There is little evidence of allometric growth. The use of a single measurement appreciably reduces the amount of work involved in leaf area estimation and thus the cost of measurement.

Gollifer and Brown (1974) attempted to define a disease index for taro leaf blight using a field assessment key for estimating the percentage of the leaf area damaged by the disease. The amount of disease was assessed on each fully expanded leaf and the mean disease rating for each plant was calculated by dividing the sum of the assessments for each leaf by the total number of leaves examined.

Leaves are produced at the top of the plant axis and appear to move down it as they are displaced by new ones. The severity of the disease on each leaf increases as it ages and the longer it has been exposed to the fungus. It can be misleading to average the disease scores on different leaves unless there is a constant proportional relationship between the severity of the disease at different levels within the plant canopy, and a constant number of leaves per plant in each sample. This is because if any plant has more leaves than the others, its mean disease score will be disproportionately weighted by leaves at the bottom of the plant axis which are more severely affected by the disease.

It may be possible to assess the disease on a single specified leaf (*e.g.* the second fully-expanded leaf, counting from the top). However, the index suggested by Gollifer and Brown (1974) omits consideration of the most important effect of the disease: the total loss of leaves at the base of the plant. A disease score summed over all the available leaves would underestimate the level of disease in severely affected plants since they have fewer leaves.

The total number of leaves lost at the bottom of the plant is more directly related to yield loss than partial loss of effective leaf areas further up the axis, although the latter could be used as a proxy variable. The relationship between the two would need to be determined by experiment for each cultivar (since different cultivars have different numbers of leaves) in the same way that the leaf area model has to be calibrated for each cultivar because leaves of different cultivars have slightly different shapes.

Previous attempts to define a disease index for taro leaf blight have thus been either excessively elaborate (estimation of total leaf area using an over-parameterised model, and correction for areas damaged by blight) or trivial (because the index can not be related to variation in yield). In this paper, the effect of leaf blight on the number of leaves which the taro plant can support is examined.

MATERIALS AND METHODS

Setts of the taro cultivar 'K264' were planted at 0.8 m × 0.8 m spacing in a randomized complete block design with five replications of four treatments (30 plants/plot). The site was newly-cleared secondary bush at LAES. Growth and yield data were recorded on the central 12 plants of each plot. An additional guard row of *Xanthosoma sagittifolium* ("kongkong" or "singapore" taro), which is a more vigorous plant species not affected by taro leaf blight, was used to separate the plots. This helped to restrict the movement of inoculum between plots.

Damage by taro beetle (*Papuana* sp.) was partly controlled using two applications of Lindane granules (6 per cent hexachlorocyclohexane, HCH), at planting and at 49 days after planting (DAP) (1 g/plant). No fertilizer was applied. The plants were sprayed twice with 0.5% Ridomil plus 72WP, at 48 DAP and at 55 DAP to eliminate any natural blight infection. When the plants were assessed at 69 DAP none showed any blight symptoms.

The four treatments were labelled "A", "B", "C" and "D". Treatments A, B and C were inoculated with a zoospore suspension of *P. colocasiae* at 78 DAP, 105 DAP and 133 DAP respectively. Treatment D was an uninoculated control plot. Treatments B, C and D were sprayed fortnightly after planting with 0.3% Ridomil plus 72 WP, except that the final spray of treatments B and C preceding inoculation was omitted. Treatment B was sprayed once, treatment C three times, and treatment D nine times.

The plants were scored for the number of leaves on the main stem and the presence or absence of blight ($+/-$) approximately every 3 weeks starting at 43 DAP. On each occasion, the top leaf of each plant was tagged with a loop of string so that the rate at which new leaves were produced, and old ones lost, could be determined. The main corms were harvested at 235 DAP.

RESULTS

In general, the number of leaves per plant in each of the plots increased at a similar rate until spraying with fungicide was stopped and the plants were inoculated (see Table 1). Following inoculation, the number of leaves

Table 1.–**Mean number of taro leaves per plant (n=60) at different days after planting. The treatments are different times of inoculation with taro leaf blight.**

Days after planting	Days after planting until inoculation (no. leaves/plant)			
	78	105	133	no inoculation (1)
43	2.69a (2)	2.78a	2.82a	2.73a
69	3.58a	3.50a	3.39a	3.57a
89	3.44b	4.30a	4.06ab	4.38a
110	3.14b	4.42a	4.25a	4.27a
131	2.48bc	2.38b	3.17ac	3.50a
152	2.41b	2.30b	2.65ab	2.97a
174	2.45b	2.35b	2.63b	3.65a
196	2.27b	2.12b	2.35b	3.02a
216	1.85b	1.93b	1.97b	2.53a

(1) Uninoculated plots were sprayed with 0.3% Ridomil plus 72 WP at fortnightly intervals

(2) In each row, means followed by a common letter are not significantly different (P > 0.01) using Duncan's Multiple Range Test

per plant declined until an equilibrium rate of leaf loss was achieved within 3–6 weeks. After the equilibration period, the number of leaves per plant in all treated plots was similar irrespective of the time of inoculation, and significantly below that for the control plots.

The effect of leaf blight was to reduce the number of older leaves at the bottom of the plant axis (see Table 2). Leaf blight had no effect on the rate of leaf production. The reduction in the number of leaves caused by blight (y) at different times during the crop cycle is directly proportional to the number of leaves which a healthy plant has at that time (x):

$$y = -0.28 + 0.33x \qquad (2)$$
$$(r = 0.72, n = 7, P < 0.05)$$

At harvest, the yield was significantly reduced (P < 0.01) in all the inoculated plots (see Table 3). The yields from inoculated plots were not significantly different from each other,

Table 2.–**Comparison of the number of top and bottom leaves in unsprayed and leaf blight diseased and ridomil sprayed taro plants. Top leaves are those higher on the plant axis than a tag attached three weeks previously; bottom leaves are those below and including the tagged leaf.**

Leaves	Days after planting until inoculation (no. leaves/plant)							
	69	89	110	131	152	174	196	216
Sprayed total(1)	3.57	4.38	4.27	3.50	2.97	3.65	3.02	2.53
top	3.31	2.20	2.24	2.17	1.58	2.03	1.70	1.25
bottom	0.32	2.28	2.00	1.35	1.37	1.64	1.32	1.29
Diseased total(1)	3.58	3.44	3.14	2.48	2.41	2.45	2.27	1.85
top	3.26	2.26	2.41	2.12	1.66	1.97	1.57	1.22
bottom	0.39	1.28	0.78	0.46	0.79	0.48	0.71	0.66
(sprayed – diseased) top	0.05 ns(2)	−0.06 ns	−0.17 ns	0.05 ns	−0.08 ns	0.06 ns	0.13 ns	0.03 ns
(sprayed – diseased) bottom	−0.07 n.s.	1.00 ***	1.22 ***	0.89 ***	0.58 ***	1.16 ***	0.61 ***	0.63 ***
% reduction	—	23	29	25	20	32	20	25

(1) The sum of the top and bottom leaves may not equal the total number of leaves as some leaves above the tag were dead.
(2) ns = non-significant (P > 0.05; *** = P < 0.001)

Table 3.–**Mean yield of taro corms following inoculation with taro leaf blight at different times.**

Time of inoculation (DAP)	Mean corm weight (g)	Yield (t/ha)
78	260	4.1
105	260	4.1
133	300	4.7
no inoculation(1)	392	6.1
L.S.D. (P = 0.01)	73.4	1.1

(1) Uninoculated plots were sprayed with 0.3% Ridomil plus 72 WP at fortnightly intervals.

although the yield from plots inoculated at 133 DAP was higher than the yields from plots inoculated at 78 DAP and 105 DAP.

DISCUSSION

The present experiment demonstrates the value of leaf number (rather than leaf area) for monitoring the progress of the disease. Leaf blight increases the rate at which older leaves disappear. Leaf number is easier, and thus less costly, to estimate than total leaf area (whether or not this is corrected for the loss of effective area around leaf blight lesions), and it is a direct measure of the major component of leaf area affected by the disease. The proportional reduction in leaf number per plant provides a partial disease index which is neither elaborate nor trivial.

The total number of leaves on healthy plants reflects the balance between the rate of leaf production at the top of the plant axis (dependent on intrinsic morphogenetic patterns and crop nutrition) and the rate of natural senescence. The rate of destruction of leaves by leaf blight depends on the age structure of the leaf population and the susceptibility of the host tissue to attack by leaf blight (both of which may vary between cultivars), and the presence of weather patterns (high rainfall, high humidity) favouring pathogen development.

However, it is clear from Table 1 that, following inoculation of a single cultivar at different times, the reduction in leaf number rapidly equilibrates. At harvest time, it is not possible to distinguish different disease progress curves simply from the number of leaves remaining.

The equilibrium rate of leaf fall was achieved within 3–6 weeks of inoculation. The very rapid rate of equilibration in leaf number per plant at the reduced level following inoculation at 105 DAP (treatment B), the drop in leaf number per plant in treatment C prior to inoculation, and the reduction in leaf number per plant in the control plots between 120 DAP and 160 DAP all appear to have been related to heavy rainfall which occurred between 107 and 126 DAP. Some contamination from adjacent infected plots probably occurred slightly before C plots were inoculated, and at 131 DAP some plants in the sprayed (control) plots were also infected by leaf blight. By 152 DAP, the C treated plants had equilibrated at the lower leaf number and the disease in the control plots had been eliminated by the routine spray regimen. Leaf number per plant in control plots did not recover however until 174 DAP. Although this temporary loss of control in the experiment might have reduced slightly the apparent rate of yield loss generated by the disease, it does serve to emphasise the intrinsic stability of the taro-leaf blight system.

The high correlation between the number of leaves lost to blight and the number of leaves on plants kept free from disease by routine application of Ridomil plus has important implications for the design of disease management strategies involving intervention during the growing season, for example through the use of fungicides.

During the first two months of the crop cycle, there are few leaves (from zero to three) and there is little blight damage. Leaf numbers then rapidly increase and remain high throughout the main part of the season, subsequently declining as the crop approaches maturity. Thus, the potential rate of yield accumulation is greatest during mid-season when leaf numbers are highest. The potential for reduction in

48

leaf number caused by blight is also highest at that time.

In areas where taro leaf blight is endemic, pesticide use should be concentrated in the period of maximum leaf number (2–5 months after planting in a 7 month crop). Treatment before two months will have little effect if the crop becomes infected later. Treatments applied during the last two months of the crop cycle will also have a comparatively slight effect on yield because (1) the potential rate of yield loss accumulation is much lower during this period, and (2) the final sprays applied during the main part of the growing season will have a residual protective effect. Restriction of fungicide cover to the middle of the growing season will reduce the total number of spray applications required to achieve a worthwhile yield response, although the final level of disease in the crop at harvest may be indistinguishable in treated and untreated plots.

REFERENCES

48

BOURKE, R.M., MORRIS, J. and BONGBONG, S. (1976). A note on the relationship between taro (*Colocasia esculenta*) leaf area and the AA' leaf measurement. *Tropical Root and Tuber Crop Newsletter*, **9**: 51–54.

BOURKE, R.M. and PERRY, C.H. (1976). Influence of sett size on growth and yield of taro (*Colocasia esculenta*). *Papua New Guinea Agricultural Journal*, **27**: 115–120.

CAESAR, K. (1980). Growth and development of *Xanthosoma* and *Colocasia* under different light and water conditions. *Field Crops Research*, **3**: 235–244.

CHAPMAN, T. (1964). A note on the measurement of leaf area of the tannia (*Xanthosoma sagittifolium*). *Tropical Agriculture Trinidad*, **41**: 351–352.

COX, P.G. and KASIMANI, C. (1988). Control of taro leaf blight using metalaxyl. *Tropical Pest Management*, **34**: 81–84.

GOLLIFER, D.E. and BROWN, J.F. (1974). *Phytophthora* leaf blight of *Colocasia esculenta* in the British Solomon Islands. *Papua New Guinea Agricultural Journal*, **25**: 6–11.

JACKSON, G.V.H., GOLLIFER D.E. and NEWHOOK F.J. (1980). Studies on the taro leaf blight fungus *Phytophthora colocasiae* in Solomon Islands: control by fungicides and spacing. *Annals of applied Biology*, **96**: 1–10.