ECONOMIC EVALUATION OF FUNGICIDE APPLICATION ON TARO (*Colocasia esculenta*) LEAF BLIGHT

Tarla D N¹*, Fon D E², Takumbo E N¹ and Fontem D A¹,³

¹Department of Plant Protection, FASA, University of Dschang.
²Department of Agricultural Economics, FASA, University of Dschang
³Delaware State University, Delaware, USA.

Received – April 26, 2014; Revision – May 05, 2014, Accepted – May 26, 2014

ABSTRACT

Taro is an important crop in Cameroon but yields of the crop has severely affected by pests and diseases especially leaf blight. An economic evaluation of fungicide applications on taro blight was conducted in Dschang, Cameroon, during the 2012 cropping season. A split-plot design was used, with two factors; fungicide and cultivar, replicated three times. Whole plots were assigned to five fungicide spray schedules (7, 14, 21, 28-day, and non-treated) while sub-plots were assigned to two taro cultivars; the dark green petioles (“Ibo coco”) cultivar and the light green petioles small leaves (“Ehkoueh’lah”) cultivar. A fungicide, Plantomil 72 WP was applied at 3.33 kg ha⁻¹. Blight severity was scored weekly in every sub-plot, and yields were obtained at harvest. Data was subjected to the analysis of variance. Standardized area under disease progress curve (SAUDPC) was high (p = 0.005) in control plots compared to sprayed plots of the cultivars. The high SAUDPC values were correlated with low yields (16.11 t/ha) in control plots of “Ibo coco” compared to high yields (60.44 to 62.11 t/ha) in sprayed plots. For “Ehkoueh’lah”, yield differences between control and sprayed plots were not high, 33.11 tha⁻¹ in the control compared to 46.83 to 49.06 tha⁻¹ in sprayed plots. The highest yield increase of 74.06 and 32.51 % for “Ibo coco” and “Ehkoueh’lah”, respectively was obtained from 7-day sprayed plots. Economic analysis revealed that a 28-day fungicide spray frequency had the highest rate of return, 13.78 and 6.63 and net benefits of 8.26 and 4.76 million FCFAha⁻¹ for “Ibo coco” and “Ehkoueh’lah”, respectively. Thus, taro leaf blight can be managed with monthly applications of fungicide.

* Corresponding author
E-mail: tarlada@yahoo.fr (Tarla D N)

Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.
1 Introduction

Taro (Colocasia esculenta (L.) Schott) is an important staple or subsistence crop appreciated by millions of people from developing countries (Mishra et al., 2008). It is consumed as a staple crop in West Africa, particularly in Ghana (Joshua, 2010), Nigeria (Bandyopadhyay et al., 2011) and Cameroon (Fontem & Mbong, 2011). All parts of the plant including corm, cormels, rhizome, stalk, leaves and flowers are edible and contain abundant starch (Bose et al., 2003). It is the fourteenth most consumed vegetable worldwide (Rao et al., 2010). In 2012, the total world’s production was estimated at 10 million tonnes. Cameroon was the fourth taro producer in the world, and the third highest taro producer in Africa. It contributed 1.6 million tonnes to Africa’s production of 7 million tonnes. Taro is cultivated in all regions of Cameroon (FAO, 2014).

Taro leaf blight, caused by Phytophthora colocasiae Raciborski is the most destructive disease responsible for heavy yield losses (25 to 50 %) of taro in many countries (Gadre & Joshi, 2003). In addition, this pathogen can also causes a serious post-harvest decay of taro corms (Misra, 1997). The disease is the major constraint to taro production and is capable of compelling farmers to abandon their crop fields or rotate to other staple crops (Jackson, 1996). In Africa, the disease caused many farmers to abandon their fields.

Relying on the removal of all leaves with lesions as a method of control would quickly lead to a complete defoliation of the crop with consequent effects on yield (Adams, 1999). Desirable cultural characteristics and quality are often lost during breeding to produce resistant cultivars; meanwhile the choice of taro cultivars by farmers is driven by their personal tastes and market considerations (Brooks, 2005; Nelson et al., 2011). With the above weaknesses, the cultural method and the use of resistance varieties cannot control the disease satisfactorily to provide enough tubers needed by the fast growing population. Thus, an integrated disease management strategy, which seeks to protect the environment, may be of importance. Among these methods, the rational use of fungicides to control diseases is the fastest management method. This study was carried out to assess technical and economic evaluation of fungicide applications on taro blight.

2 Materials and methods

2.1 Cultural procedure

Field experiments were conducted during 2012 cropping season in Dschang (5° 26’ N, 10° 04'E, and 1400 m altitude), Cameroon. Preceding crops in the site were taro (Colocasia esculenta), beans (Phaseolus vulgaris) and maize (Zea mays). Weed species in and around the site were Ageratum houstonianum, Bidens pilosa, Setaria spp., Brachiaria spp. A randomized Split-plot design was used with two factors (fungicide and cultivar) replicated three times. Fungicide regime was assigned to main plots while cultivars occupied sub-plots. Main plot measuring 4 * 2.5 m, were separated by a taro-free zone 1 m wide to limit inter plot interference.

Two morphologically distinct taro cultivars i.e. “Ibo coco” (Dark green petioles cultivar) and “Ekhoue‘lah” (light green petioles small leaves cultivar) which were grown in the Western highlands of Cameroon used in study. The soil was ploughed to a depth of 30 cm and taro seeds were planted on the March 20, at the spacing of 1 * 0.5 m (20000 plants ha⁻¹). Poultry manure was applied a day before planting, at the rate of 10t ha⁻¹ while the second poultry manure application (6 t ha⁻¹) was conducted three months after planting. The manure was spread round the plant but 5 cm away from the stem. Mineral fertilizer (NPK 12:11:18 + 2.7 MgO+8 S) was applied at the rate of 800 kg ha⁻¹ 3 months after planting. The field was weeded both manually and chemically. Shielded sprays of paraquat (2.5 1 ha⁻¹) coupled with hand weeding was used to control weeds before canopy formation. Subsequent weeding was manual and carried out when necessary. Moulding was implemented after mineral fertilizer application. Crops were harvested on the November 4 and December 4, 2012 (7.5 and 8.5 months after planting) for “Ibo coco” and “Ekhoue‘lah”, respectively, when most of the leaves had senesced. The corms were separated from the petioles, counted and marketable tubers weighed for each sub-plot. Marketable tuber yields were expressed as tonnes fresh weight per hectare. Yield increases attributed to fungicide protection were calculated as follows:

\[
\text{Yield increase (\%)} = \left( \frac{\text{Yield of sprayed} - \text{Yield of non-treated}}{\text{Yield of sprayed}} \right) \times 100
\]

2.2 Fungicide application

Fungicide applications were initiated the very day the first symptoms of taro blight were observed. This was on July 8, 2012, 110 days after planting (DAP). Plantomil 72 WP was applied at the rate of 3.33kg/ha (50 g in 15 L for 150 m²) using a Jacto knapsack sprayer that delivers 1000 L ha⁻¹ at a maximum pressure of 4 kg cm⁻². The nozzle was the hollow cone type. In order to make the fungicide stick to the leaves, an adhesive, Polyfix (aqueous solution of polyvinyl alcohol) was added to the spray mixture at the rate of 1.33 L ha⁻¹ (20 ml 15L⁻¹ 150 m⁻²). Plots were sprayed on a 7, 14, 21 and 28-day schedule, while control plots were left non-treated. A protective screen was placed between sprayed and non-treated plots to control fungicide drift.

2.3 Disease evaluation

The crop was exposed to naturally-occurring inocula in the field. Disease severity (percent leaf area diseased) was scored...
weekly on three central row plants of each sub-plot with the aid of a 1-9 rating scale, developed by the Potato International Centre (CIP). Seventeen and twenty-one weekly ratings, initiated from the first foliar taro blight symptoms were scored for “Ibo coco” and “Ehkoueh’lah”, respectively per sub-plot. Values for standardised area under diseased-progress curves (SAUDPC) were calculated from the severity data according to the formula suggested by Campbell and Madden (1990).

\[
SAUDPC = \frac{\sum_{i=1}^{n-1} (y_{i} + y_{i+1}) (t_{i+1} - t_{i})}{2 (t_{n} - t_{1})}
\]

Where; \(y_{i}\): disease severity, \(t_{i}\): time in days and \(t_{n}-t_{1}\): duration of the epidemic in days

2.4 Economic assessment of fungicide applications

Economic analyses were conducted for costs and returns to each fungicide spray frequency on each cultivar. The market price for a bucket (15 kg) of “Ibo coco” was 3000 FCFA (200 FCFA kg\(^{-1}\)) and 6000 FCFA (400 FCFA kg\(^{-1}\)) for “Ehkoueh’lah”, obtained from interviewing at random 50 taro producers and 50 local vendors. This price was used to estimate the total returns. Increase in taro yield over non-treated plots was assumed to be solely due to fungicide applications.

The cost of protecting one hectare of taro with fungicide (CP) was calculated as follows:

\[
CP = (RF \times CF) + CL \times n
\]

Where RF = rate of fungicide applied (3.33 kg,ha\(^{-1}\)), CF = cost of a kg of fungicide (16,000 FCFA), CL = cost of labour used in protecting a hectare of taro, cost of adhesive and depreciation of the sprayer (66,000 FCFA) and \(n\) =number of fungicide applications.

Total returns were the values of the marketable yields obtained in each treatment. A net return for each spray frequency was calculated by deducting the cost of fungicide protection from the total return of that spray frequency.

The net increase in revenue due to fungicides treatment was assessed by deducting the net return from the non-treated plot from that obtained in each fungicide spray frequency.

The rate of return (net benefit/cost of fungicide protection ratio) was calculated, to determine the most economically efficient fungicide spray frequency.

2.5 Data analysis

Disease progress curves for taro blight evolution were constructed for each fungicide sprayed frequency. Standardized areas under diseased-progress curves (SAUDPC) and yields for each fungicide spray frequency were subjected to the analysis of variance (ANOVA) using GENSTAT. Means were separated using Fischer’s least significance difference at \(P=0.05\).

3 Results

3.1 Effect of variety on the severity of taro blight

Taro blight severity increased rapidly immediately after the appearance of the first symptoms. The rate of increase was higher on “Ibo coco” as compared to “Ehkoueh’lah” (Figure 1). The rate of increase of taro blight severity started decreasing from day 152 after planting (42 days after the first symptoms). The final disease on Ibo coco and Ehkoueh’lah was 0.94 and 0.76 respectively. The SAUDPC on Ibo coco (0.75) was higher than that of “Ehkoueh’lah” (0.63), thus, taro blight severity was higher on Ibo coco than on “Ehkoueh’lah”. An analysis of variance showered a significant difference (\(p<0.001\)) in the SAUDPC on the control plots of the cultivars.

![Figure 1 Progression of taro leaf blight in two taro cultivars (“Ibo coco” and “Ehkoueh’lah”) not treated with Plantomil 72 WP](image-url)
Figure 2 Progression of taro blight on “Ibo coco” (a) and “Ehkoueh’lah” (b) subjected to five fungicide spray regimes.

Table 1 Effect of Plantomil 72 WP spray frequency on the standardized area under diseases progress curve (SAUDPC) of taro blight.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Spray schedule</th>
<th>SAUDPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Ibo coco”</td>
<td>7-day</td>
<td>0.11b</td>
</tr>
<tr>
<td></td>
<td>14-day</td>
<td>0.12b</td>
</tr>
<tr>
<td></td>
<td>21-day</td>
<td>0.16b</td>
</tr>
<tr>
<td></td>
<td>28-day</td>
<td>0.19b</td>
</tr>
<tr>
<td></td>
<td>Non-treated</td>
<td>0.75a</td>
</tr>
<tr>
<td>“Ehkoueh’lah”</td>
<td>7-day</td>
<td>0.16b</td>
</tr>
<tr>
<td></td>
<td>14-day</td>
<td>0.18b</td>
</tr>
<tr>
<td></td>
<td>21-day</td>
<td>0.19b</td>
</tr>
<tr>
<td></td>
<td>28-day</td>
<td>0.19b</td>
</tr>
<tr>
<td></td>
<td>Non-treated</td>
<td>0.63a</td>
</tr>
</tbody>
</table>

Means of each variety with the same letter have no significant difference (p<0.05) according to Fisher’s LSD.

Table 2 Effect of fungicide and variety on the yield, number of tubers/ha and mean tuber weight of “Ibo coco” and “Ehkoueh’lah” cultivars of taro.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Spray schedule</th>
<th>Yield (t/ha)</th>
<th>Number of tubers x1000/ha</th>
<th>Mean tuber weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Ibo coco”</td>
<td>Non-treated</td>
<td>16.11a</td>
<td>140a</td>
<td>114.96a</td>
</tr>
<tr>
<td></td>
<td>7-day</td>
<td>62.11b</td>
<td>373b</td>
<td>166.90b</td>
</tr>
<tr>
<td></td>
<td>14-day</td>
<td>61.22b</td>
<td>377b</td>
<td>162.32b</td>
</tr>
<tr>
<td></td>
<td>21-day</td>
<td>60.78b</td>
<td>366b</td>
<td>166.38b</td>
</tr>
<tr>
<td></td>
<td>28-day</td>
<td>60.44b</td>
<td>377b</td>
<td>161.02b</td>
</tr>
<tr>
<td>“Ehkoueh’lah”</td>
<td>Non-treated</td>
<td>33.11a</td>
<td>407 a</td>
<td>81.90a</td>
</tr>
<tr>
<td></td>
<td>7-day</td>
<td>49.06b</td>
<td>436 a</td>
<td>112.59b</td>
</tr>
<tr>
<td></td>
<td>14-day</td>
<td>48.44b</td>
<td>441 a</td>
<td>109.83b</td>
</tr>
<tr>
<td></td>
<td>21-day</td>
<td>46.78b</td>
<td>427 a</td>
<td>109.43b</td>
</tr>
<tr>
<td></td>
<td>28-day</td>
<td>46.83b</td>
<td>417 a</td>
<td>112.06b</td>
</tr>
</tbody>
</table>

Means of each variety in the same column with the same letter are not significantly different (p<0.05) according to Fisher’s LSD.
Economic evaluation of fungicide application on taro (Colocasia esculenta) leaf blight.

3.2 Effect of fungicide spray frequency on taro blight severity

Taro blight severity on both cultivars was lower in sprayed plots than control plots. (Figure 2) The final disease was below 25% for sprayed plots contrary to non-treated plots, which had 94 and 77% for “Ibo coco” and “Ehkoueh’lah”, respectively. An analysis of variance revealed a highly significance (p < 0.001) effect of spray frequency on SAUDPC. Non-treated plots were significantly different from sprayed plots at P < 0.001. There existed no significant different (p< 0.05) between sprayed plots of each cultivar (Table 1).

3.3 Effect of fungicide and cultivar on taro yields

Non-treated plots gave lower yields, low mean tuber weight and fewer tubers. For both cultivars, sprayed plots showed an increase in yield as a respond to increased spray frequency. However, yields, number of tubers and mean tuber weight for each cultivar were not significantly different (P< 0.05) in sprayed plots (Table 2). Yields of “Ibo coco” and mean tuber weight were higher in sprayed plots, compared to “Ehkoueh’lah”. Contrary yields of “Ehkoueh’lah” were higher compared to “Ibo coco” yields in control plots. “Ehkoueh’lah” produced many tubers both in sprayed and in non-treated plots though with lower mean tuber weight in the later. There was no significant difference in the number of tubers of “Ehkoueh’lah” in sprayed and non-treated plots.

Yield increases attributed to fungicide are presented in Table 3. Yield increases were higher with increased spray frequency in both cultivars. Yield increases in “Ibo coco” were higher than in “Ehkoueh’lah”. Weekly fungicide applications resulted in the highest yield increase of 74.06 and 32.51% in “Ibo coco” and “Ehkoueh’lah”, respectively.

3.4 Economic analysis of fungicide management

Both net return and cost of fungicide protection increased with the number of fungicide applications (Table 4). Total returns were higher for “Ehkoueh’lah” due to it higher market value. Net return was lower for “Ehkoueh’lah” due to high total return obtained from non-treated plots compared to “Ibo coco”. For both cultivars, net benefit increased with decreased number of fungicide applications, because high costs of fungicide protection were incurred when the number of fungicide application increased. The highest net benefit of 8.27 million FCFA/ha was obtained in plots sprayed once every month for “Ibo coco” and 4.81 million FCFA/ha in plots sprayed once every two weeks for “Ehkoueh’lah”. For both cultivars, the least net benefit was obtained when plots were sprayed on weekly bases. The rate of return in both cultivars was highest when plots were sprayed once every month. “Ibo coco” gave the highest rate of return of 13.78. Though 14-day spray frequency on “Ehkoueh’lah” gave the highest net benefit, the highest rate of return (6.63) was obtained from monthly spray schedule to manage taro blight.

4 Discussions

Taro blight was more severe in non-treated plots of each cultivar. This is supported by the high SAUDPC registered by non-treated plots of each cultivar. Among the cultivars “Ibo...
coco” was more susceptible to taro blight. This can be explained by a high (0.75) SAUDPC in control plots of the “Ibo coco” cultivar compared to a low (0.63) SAUDPC in control plots of the “Ehkoueh’lah” cultivar. Sprayed plots though received fungicide at different frequencies showed no significant differences amongst themselves for each cultivar. Sprayed plots of each cultivar had their final disease below 25%. This implies that fungicide reduced the growth rate of taro blight on these plots up to the extent that the severity of the disease could not go above 25% before harvest. Thus it can be concluded that Plantomil Plus 72 WP greatly reduced the severity of taro blight, even when applied at monthly intervals at the rate of 3.33 kg ha\(^{-1}\) kg/ha. Cox Kasimani (1988) and Ghosh and Pan (1991) reported that taro blight was effectively controlled when Ridomil Plus 72 WP was applied at two-week intervals in Papua New Guinea. It was equally reported in 1990 that five applications of Ridomil Plus (3 kg ha\(^{-1}\)) at three-week interval resulted in an increase of almost 50% in tuber yields (Cox & Kasimani, 1990). Leaf losses of up to 93% were recorded in non-treated plots of the “Ibo coco”. This goes in line with what Gadre & Joshi (2003) reported. Fontem & Schippers (2004) reported that the same active ingredients, metalaxyl and copper as Ridomil Plus 72 WP significantly reduced late blight (caused by \textit{P. infestans (Mont.) de Bary}) severity on potato.

Yields were significantly different (\(p < 0.0021\)) between sprayed and non-treated plots for each cultivar. For “Ibo coco” yields were 16.11t ha\(^{-1}\) in control plots and between 60.44 - 62.11 t ha\(^{-1}\) in sprayed plots. There was no significant different between yields in sprayed plots meaning that there was no block effect. The high difference in yields between sprayed and non-treated plots was due to a high taro blight severity in non-treated plots, which greatly reduced the number and surface area of functional leaves, hence, a reduction in photosynthesis. For “Ehkoueh’lah”, the difference between non-treated and sprayed plots was not as high as in “Ibo coco”. Yields were 33.11 t ha\(^{-1}\) in non-treated plots and between 46.83-49.06 in sprayed plots. Though taro blight severity was high in non-treated plots of “Ehkoueh’lah”, yields were not greatly reduced. Thus, “Ehkoueh’lah” tolerated the disease as compared to “Ibo coco”.

Number of tubers/ha and mean tuber weight for “Ibo coco” plots was very much affected, mean tuber weight and number of tubers/ha decreased with increased disease severity. The disease resulted to smaller tubers in non-treated plots which are not very much appreciated by consumers. There was no significant different in the number of tubers/ha in “Ehkoueh’lah” plots. The effect of the disease was shifted to the mean tuber weight. Non-treated plots gave smaller tubers. Yield increases were high in the “Ibo coco” cultivar. This improvement were 74.06, 73.69, 73.49 and 73.35% for 7-day, 14-day, 21-day and 28-day fungicide spray schedules, respectively. Yield increases were low in sprayed plots of the “Ehkoueh’lah” cultivar; these increments were 32.5, 31.6, 29.22 and 29.3% for 1-week, 2-week, 3-week and 4-week fungicide application intervals. This percentage increases falls in the range of yield losses reported by Gadre & Joshi (2003) in many Pacific countries. Guarino (2012) reported taro yield losses of up to 90% in Cameroon. In some parts of the North West and South West Regions of Cameroon, the disease damaged the farms completely and the farmers have stopped the cultivation of the crop since then. Fontem et al. (1996) reported yield losses of 100% of tomato fruits due to late blight caused by \textit{P. infestans}. Later on, Fontem & Schippers (2004) reported a total damage of huckleberry nurseries due to late blight caused by \textit{P. infestans}. Economic analysis revealed high returns in plots sprayed at weekly intervals, 9.20 and 6.38 million/ha in “Ibo coco” and “Ehkoueh’lah” plots respectively. Net benefit was rather higher (8.27 million FCFA) in “Ibo coco” plots sprayed once every month and 4.81 million FCFA in “Ehkoueh’lah” plots sprayed once every two weeks. Based only on net benefit, a monthly spray interval and a 2-week sprayed interval could be adopted for the control of taro blight on the “Ibo coco” and the “Ehkoueh’lah” cultivar respectively because these spray intervals yielded high revenue. This will however, be wrong; because the rate of return is better placed to say which spray frequency is more economical. Both cultivars showed a high rate of return when plots were sprayed at monthly intervals. Monthly sprayed plots of the “Ibo coco” and the “Ehkoueh’lah” gave rates of return of 13.78 and 6.63 million FCFA ha\(^{-1}\), respectively. This implies that every franc spent in protecting the crop was recovered 13.78 times for “Ibo coco” and 6.63 times for “Ehkoueh’lah”. Tarla et al (2011) reported a net return of 2.40 million FCFA ha\(^{-1}\) and a rate of return of 15.20 when the same active ingredients were used against huckleberry late blight. Spray regimes with high rates of return are economical and environmentally friendly since less fungicide is discharged to the environment.

**Conclusions and Recommendations**

Taro blight is a yield-limiting constraint in taro production in Cameroon; this is supported by high yield increases of up to 74.06%, observed in sprayed plots of “Ibo coco”. Fungicide applied at the rate of 3.33 kg/ha significantly reduced taro blight severity in both cultivars. Ehkoueh’lah” cultivar is more tolerant to taro blight compared to the “Ibo coco” cultivar. Economically, the monthly fungicide spray schedule gave high returns of 13.78 and 6.63 million FCFA/ha for “Ibo coco” and “Ehkoueh’lah” cultivars respectively, suggesting the profitability of applying this fungicide against taro blight. Based on the high rate of return recorded by “Ibo coco”, this cultivar is recommended to growers with month application of Plantomil Plus 72.

**Acknowledgement**

Authors grateful thank Mr Nintai Anthony Ndi of the Faculty of Agronomy and Agricultural Sciences (FASA) for field assistance.
References


