Effect of planting period cultivar on taro (Colocasia esculenta (L.) Schott) late blight caused by Phytophthora colocasiae Raciborski

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Accepted 23 December, 2013

Taro (Colocasia esculenta) is an important but Taro Leaf Blight (TLB) caused by Phytophthora colocasiae became the most destructive disease production since 2010. To assess the influence of the planting period on disease severity yield, trials were conducted in Dschang, Cameroon using complete block design with four blocks, four treatments two factors (cultivar planting period) was used. Plots were occupied by four cultivars; Makoumba, Ehkwan’frè, Ekhoueh’déh Ekhoueh’lah. TLB severity was scored at weekly with the aid of the 1-9 rating scale. Mean yields St Ardized Area under Disease-Progress Curve (SAUDPCs) were submitted to analyses of the variances using SPSS. SAUDPC was higher during season 2 (SAUDPC > 56.85%) than in season 1 (SAUDPC < 16.30%). Cultivar Makoumba was more susceptible followed by cultivar Ehkwan’frè. The highest values of SAUDPC corresponded to low yield low number of tubers /ha. The highest yield was obtained with cultivar Makoumba (61.81 t/ha) during season 1. The maximum yield increased due to the shifting of the planting period was 46.88 t/ha. The observations have shown that the shifting of the planting period of three months before the beginning of rains can be used to control TLB.

Keys words: Taro, Phytophthora colocasiae, taro leaf blight, season, cultivar, severity.

INTRODUCTION

Taro (Colocasia esculenta (L.) Schott), an Araceae, is a tuber crop that is highly cultivated in tropical regions of Africa, India, Asia, Caribbean, Pacific South America (FAOSTAT, 2008; Rodriguez-Mira et al., 2011). The world production is estimated at 12 million tonnes on a surface area of 2 million hectares (FAOSTAT, 2011a). FAOSTAT (2011b) estimates that Cameroon produced 1.7 million tonnes of taro macabo (Xanthosoma sagittifolium (L.) Schott) in 2009 with an average yield of 10 t/ha.

Taro is grown for its tuber leaves. It is a source of income to the growers while its leaves are used to treat tuberculosis, gastric ulcers, lung congestion fungal infections (Carmichael, 2008; Sharma et al., 2008; CIRAD, 2011; Mbong et al, 2013).

Despite the economic socio-cultural importance of taro in the world, taro leaf blight (TLB) is a serious yield limiting factor. The disease first appeared in 1900 in Java island other Asian, Pacific, African and American Regions such as Taiwan (1911), Philippines (1916), Guam (1918), Hawaii (1920), Samoa (1993) (Brunt et al., 2001). Recent epidemics include its appearances in Equatorial Guinea (2005), Nigeria Ghana (2009) (B yopadhyay and Sharma, 2011; Omane et al., 2012). It appeared in Cameroon in 2010 (Fontem and Mbong, 2011; Mbong et al, 2013) causing a general panic to its citizens some abandon their farms refused the consumption of its tubers leaves. In the North West Region of Cameroon, this disease was

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attributed to witchcraft while farmers in Edea attributed it to overuse of chemicals (fertilizers pesticides) acid rain. In summary, taro became rare in the market the farmers who were eating taro regularly were forced to change while its cultural value is one of the issues that remain a problem. The price of taro rose from 250 to more than 500 frs in a year. *Phytophthora colocasiae* Raciborski was identified as the incitant of the disease (Fontem Mbong 2011; Mbong et al, 2013). It is the most important disease today in Cameroon causing yield losses of 100% in some areas with national averages estimated at 80% (MINADER, 2010).

Mishra et al., (2008) recommended chemical control but its limitation include high cost, environmental pollution, residues resistance. It is therefore the objective of this study to investigate the effect of cultural practices (planting period) resistance in managing TLB.

### Material methods

Seven morphological agronomic characteristics separate the 4 cultivars: blade length, petiole colour, colour of stain (tache) of petiolar junction, form of rhizome lateral tubers, duration of cycle, number of tubers per plant mean yields per hectare. The four cultivars used are shown in Table 1. Trails were conducted in Dschang (5.5° North, 10.05° East 1400 m above sea level). Tubers weighing 100-150 g were collected in the western high in 2011. The site selected for the experiments were never cultivated with an Araceae during the past 5 years the main vegetation consisted of *Tithonia diversifolia*, *Bidens pilosa*, *Ageratum conyzoides*, *Mimosa invisa*, *Pennisetum purpureum*, *Ageratum houstonianum*, *Amaranthus spinosus*.

The climate is a sudano-Guinean type with a long rainy season (mid-March to mid-November) a short dry season from mid–November to mid-March). Average precipitation ranges from 1800–2000 mm temperatures ranges between 21–24 °C with air humidity above 70%. The study was conducted on a ferralitic soil (Yerima and Van Ranst, 2005).

### Cultural practices

For each season, it was cleared each experimental unit measured 5*2 m was planted with a single cultivar: Makoumba; Ehkwantre; Ehkoueh’ deh Ehkoueh’lah. Tubers were sown on 13th December 2011 8th March 2012 for the first season second season respectively. Tubers were sown single per hole 50 * 100 cm apart to give a planting density of 20,000 plants /ha. Spot application of poultry manure was conducted 5 days before planting at a rate of 6.8 t/ha. Half a tonne per hectare of Mineral fertilizer (19-12-19+5B+1.2S), containing nitrogen, phosphorus, potassium, boron sulphur was applied in a 10 radius around the main petiole during hilling 101, 72 days after planting for the first second season respectively. Manual weeding was conducted from the 30 DAP at 30 days intervals. Two insecticide treatments (fenobucarb 500 g/ha) were conducted against *Tarophagus propersine* (Cicadellidae) on the 45 75 DAP for both seasons. During the first season, a motopump which delivers 10 l/s of water was used to irrigate the field twice a week from 13 December 2011 to 8 March 2012. A bamboo fence was used to control domestic animals. During the trial, a complete block design was used with 4 repetitions. Each block consisted of 4 morphologically distinct cultivars.

Crops were exposed to naturally-occurring inocula. Field observation of disease symptoms was followed by

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**Table 1. Characteristics of taro cultivars used during the trial.**

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Petioles</th>
<th>Blade size</th>
<th>Spot on petiolar junction</th>
<th>Rhizome and lateral tubers</th>
<th>Mean tubers per plant and yields (t/ha)</th>
<th>Yields (t/ha)</th>
<th>Cycle (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ehkoueh’ deh</td>
<td>violets</td>
<td>Average</td>
<td>Violet</td>
<td>Globulous Big, tapered, rounded at the apices</td>
<td>14</td>
<td>43.37</td>
<td>Intermediary early 8</td>
</tr>
<tr>
<td>Ehkwant’re</td>
<td>Light green</td>
<td>Large</td>
<td>Green</td>
<td>Cylindrical with tapered lateral of very big sizes</td>
<td>4</td>
<td>44.5</td>
<td>Late 9</td>
</tr>
<tr>
<td>Ehkoueh’lah</td>
<td>Light green</td>
<td>Small</td>
<td>Green</td>
<td>Globulous rhizomes with small lateral tubers tapered and rounded towards the apex</td>
<td>23</td>
<td>51.5</td>
<td>Intermediary early 8</td>
</tr>
<tr>
<td>Makoumba</td>
<td>Dark green</td>
<td>Small</td>
<td>Violet</td>
<td>Globulous with oval lateral tubers</td>
<td>22</td>
<td>61.81</td>
<td>Early 7.5</td>
</tr>
</tbody>
</table>

Source: Purseglove, 1972
microscopic observations to confirm the causal agent. Disease severity was collected weekly from 4 central row plants using international Potato Centre scale of 1-9. Standardised area under disease-progress curve was calculated following Campbell Madden (1990):

$$SAUDPC = \frac{\sum_{i=1}^{n-1}(Y_i + Y_{i+1})(t_{i+1} - t_i)}{2}$$

$Y_i$: Severity
$t_i$: time (days) after planting
$tn - t1$: duration (days) epidemic

Weight number of marketable tubers were registered during harvest during both seasons (223, 244, 244, 272 DAP for Makoumba, Ekhoueh‘deh, Ekhoueh’lah, Ekwan‘frè cultivars respectively). Yield loss due to change in planting period was calculated for each cultivar as follows:

$$\%YL = \frac{YS_1 - YS_2}{YS_1} \times 100$$

$YS_1$: Yield in season 1
$YS_2$: Yield in season 2.

### DATA ANALYSIS

Monthly depreciation rate of Moto pump accessories was estimated at 24 500 FCFA/ season considering that a machine is supposed to last for 48 months. A total of 27.36 litres of fuel was used during the trial a unit cost of 525 FCFA a litre giving a total of 402 190 FCFA. Labour (CL) in man-days (MD) was estimated at 672 000 FCFA when a MD was taken to be 1500 FCFA with 16 workers for 28 days. The total cost of irrigation was therefore taken to be 1 097 690 FCFA/ha.

Total revenue was estimated for irrigated: (a) non irrigated (b) experimental units. The net revenue (c) was considered to be the difference between the irrigated the non irrigated total revenue $c=a-b$. The net benefit (d) was the difference between the net revenue (c) the cost of irrigation (e). Rate of return (f) is the number of times each unit invested in irrigation brought gain ($f = d/e$).

A kilogramme of taro was considered to be 267, 400, 400, 200 FCFA for Makoumba, Ekhoueh‘deh, Ekhoueh’lah, Ekwan‘frè cultivars respectively during the first season. During the second season, the prices were 200, 333, 333 133 FCFA for Makoumba, Ekhoueh‘deh, Ekhoueh’lah Ekwan‘frè cultivars respectively (Tarla et al, 2011). Analysis of variance was conducted using GENSTAT while means were separated using the Least Significant Difference at 5% probability.

### RESULTS DISCUSSION

The first foliar symptoms appeared on all cultivars on 195, 104 DAP during the first second season respectively. TLB symptoms were characterised by necrosis on infected blades, petioles tuber rots. Petiole necrosis gave a bad odour in the field. Direct observation in the morning hours showed a white downy mildew of the sporangial mass (Fullerton and Tyson, 2004). Laboratory confirmation was followed using an ordinary light microscope at 200X revealing oval sporangia, characteristic of $P. colocasiae$.

ANOVA of SAUDPC revealed that late blight severity varied with cultivar ($p > 0.001$). In season 1, SAUDPC was very high for Makoumba (34.84%) with respect to the other cultivars; Ekwan‘frè (27, 66%), Ekhoueh‘deh (16.30%), Ekhoueh’lah (17.30%) (Table 2). In season 2, the following SAUDPC were registered: Makoumba (74.50%), Ekwan‘frè (65.11%), Ekhoueh‘ deh (56.85%) Ekhoueh’lah (59.13%). Makoumba is therefore the most susceptible variety. In Cameroon, farmers grow Makoumba more than any other cultivar.

SAUDPC was higher in the second than the first planting season. The high SAUDPC obtained in season 2 was attributed to the favourable meteorological conditions: monthly precipitation above 164.30 mm, average relative humidity above 90% mean daily temperatures below 19.86°C.

ANOVA of marketable tuber yields revealed a highly significant effect of cultivar ($p > 0.001$) (Table 3). These yields were higher during the first season than the second season. Yields were higher in season 1 compared to season 2 inversely proportional to disease intensity. These results are attributed to late blight.

However, the size number of tubers is not affected by the disease severity (Paiki, 1996).

### Table 2 : Evolution of late blight SAUDPC (%) with planting periods

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Season 1</th>
<th>Season 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ehkwan‘frè</td>
<td>27.66</td>
<td>65.12</td>
</tr>
<tr>
<td>Ekhoueh’lah</td>
<td>17.30</td>
<td>59.14</td>
</tr>
<tr>
<td>Ekhoueh‘ deh</td>
<td>16.30</td>
<td>56.86</td>
</tr>
<tr>
<td>Makoumba</td>
<td>34.84</td>
<td>74.50</td>
</tr>
<tr>
<td>LSD</td>
<td>5.88</td>
<td>6.65</td>
</tr>
</tbody>
</table>
Table 3: Influence of planting period on taro marketable tuber yields in seasons 1 and 2 (t/ha).

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Mean marketable tuber yields</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Season 1</td>
</tr>
<tr>
<td>Ehkwang’frè</td>
<td>44.50</td>
</tr>
<tr>
<td>Ehkoueh’lah</td>
<td>51.50</td>
</tr>
<tr>
<td>Ehkoueh’deh</td>
<td>43.38</td>
</tr>
<tr>
<td>Makoumba</td>
<td>61.81</td>
</tr>
<tr>
<td>LSD</td>
<td>1.70</td>
</tr>
</tbody>
</table>

Table 4: Yield loss between planting periods.

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Yield season 1</th>
<th>Yield season 2</th>
<th>Yield loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makoumba</td>
<td>61.81</td>
<td>14.94</td>
<td>75.85</td>
</tr>
<tr>
<td>Ehkwang’frè</td>
<td>44.50</td>
<td>17.57</td>
<td>60.50</td>
</tr>
<tr>
<td>Ehkoueh’deh</td>
<td>43.38</td>
<td>21.19</td>
<td>54.62</td>
</tr>
<tr>
<td>Ehkoueh’lah</td>
<td>51.50</td>
<td>33.83</td>
<td>34.28</td>
</tr>
</tbody>
</table>

Table 5: Economic analysis of a change in planting period by 3 months before the rains (x 1000 FCFA/ha).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cost of Irrigation</th>
<th>Revenue season 1</th>
<th>Revenue season 2</th>
<th>Net revenue</th>
<th>Net benefit</th>
<th>Rate of return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makoumba</td>
<td>1098</td>
<td>16 482</td>
<td>2986</td>
<td>13496</td>
<td>12399</td>
<td>11.29</td>
</tr>
<tr>
<td>Ehkwang’frè</td>
<td>1098</td>
<td>8900</td>
<td>2341</td>
<td>6559</td>
<td>5461</td>
<td>4.97</td>
</tr>
<tr>
<td>Ehkoueh’deh</td>
<td>1098</td>
<td>17 348</td>
<td>7061</td>
<td>10286</td>
<td>9189</td>
<td>8.37</td>
</tr>
<tr>
<td>Ehkoueh’lah</td>
<td>1098</td>
<td>20 600</td>
<td>11273</td>
<td>9327</td>
<td>8229</td>
<td>7.49</td>
</tr>
</tbody>
</table>

Makoumba gave the highest yields in season 1 the lowest yields in season 2. This may explain why farmers in Cameroon plant Makoumba cultivar more than any other variety. This result also confirms the fact that high-yielding cultivars are generally susceptible to disease.

These high yields were attributed to the intrinsic characteristic of each cultivar to give good yields, the fertility of the soil. In the world, mean yields are estimated at 5–6 t/ha (Kantanka, 2004) while 5 to 10 t/ha (CMA-AOC, 2011) are obtained in Africa. In experimental fields, yields are generally higher than in yields obtained in farmers’ fields.

Marketable yield losses attributed to late blight varied from 34.28 to 75.85. These values were low compared to national average of 80%. These low values can be attributed to the fact that planting in November does not eradicate the disease. Secondly, worst case scenarios are obtained in farmers’ fields due to the repeated cultivation of the same crop for many generations using the same planting material. Three years after the appearance of this disease, taro has become rare expensive leading to a change of feeding habits from the consumption of taro products to other roots tubers or other foodstuff (Table 4). Late blight (Phytophthora infestans (Mont.) de Bary) is responsible for high yield losses in vegetable fields in Cameroon. On huckleberry (Solanum scabrum Mill.), yield losses of up to 100 % have been reported in the nurseries (Fontem and Schippers, 2004) 5-46 % field damage (Fontem et al., 2003). In Cameroon, tomatoes fruit losses of about 100 % in the untreated fields have been reported (Fontem et al., 1996). Potato yield losses due to the disease can attain 71 % (Fontem and Aighewi, 1993; Fontem et al., 2001). Late blight is without thought a threat to global food security (GILB, 2001).

Economic analysis

Net benefits varied from 12 399 000 to 5 461 000 FCFA (Table 5). During the study period, only Makoumba gave a high net revenue of 13 496 000 FCFA/ha. Rates of return were high varying from 11.29 to 4.97 with the former obtained from Makoumba cultivation. Economic losses of US$ 8467 (4.2 million FCFA) (Fontem et al., 2003) €3494 (2.3 million FCFA), (Tarla et al., 2011) have been attributed to huckleberry late blight in Cameroon. These rates of return also corroborates with data registered on huckleberry (Tarla et al., 2011) proving the economic validity of the technology used.

CONCLUSIONS AND RECOMMENDATIONS

Disease severity was higher in season 2 compared to
season 1. Season 1 is not a good season for disease development. Makouma gave the highest yields with 61.81 t/ha in season 1 followed by Ehkoue'hlah (51.50 t/ha), Ehkwant'frré (44.50 t/ha) Ehkoue'deh (43.38 t/ha). Yield losses attributed to late blight varied from 34.28 to 75.85% according to the cultivar. Makouma registered the highest disease severity net benefit of 12 399 000 FCFA. Based on these results, growers should sow taro in December irrigate in order to escape the high disease pressure of the second season.

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