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Taro Leaf Blight: Disease Assessment, Farmers' Knowledge and Management Potential of Goatweed Extract in South West Cameroon

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Abstract

Leaf blight disease severely constrains the production of taro (*Colocasia esculenta* (L.) Schott) in Cameroon. Studies were conducted in seven localities in Fako Division, South West Region of Cameroon to assess the incidence and severity of the disease in taro farms using non-destructive sampling, and to document farmers' knowledge about it using a structured questionnaire. The fungicidal effect of the aqueous leaf extract of goatweed (*Ageratum conyzoides* L.) at 0 and 100% concentrations and the chemical fungicide Mancozan was tested *in-vitro*. Results revealed widespread distribution of the disease in the Region. The incidence (77.9–96.5%) and severity (51.9 – 85.6%) varied significantly ($P \leq 0.05$) across the localities. The infection rate was classified as high in four localities and very high in three. The farmers were able to identify the disease and understood its effects on taro production but they were not aware of any pesticidal plants for its management. The aqueous leaf extract (100%) of goatweed and Mancozan significantly ($P \leq 0.05$) inhibited the mycelia growth of the fungus compared to the untreated control (0%). The plant extract had the potential to control the disease although it gave moderate inhibition of the fungus (38.4% at 9 days after exposure) which was not as effective as Mancozan (100% inhibition). Goatweed could be exploited for use as a source of natural fungicide for management of the pathogen. This study provides baseline information for future studies on the disease and recognises it as a major challenge to the sustainable production of taro.

Keywords: Farmers' knowledge; Goatweed leaf extract; Incidence; Severity; Taro leaf blight disease.

1. Introduction

Taro (*Colocasia esculenta* (L.) Schott) is a tuber crop in the Araceae family, which is cultivated in tropical and sub-tropical countries. It is an ancient crop which has been a key component of livelihoods for millions of people in developing countries, especially in Africa and Southeast Asia [1]. It is mostly cultivated by small-scale farmers in the North-West, South-West and Western Regions of Cameroon. It is rich in nutrients such as carbohydrates and minerals [2]. It also has medicinal properties; for instance, it is used for the treatment of toothache and cancer [3, 4].

Crop diseases reduce agricultural productivity and food availability leading to an increase in the price; this affects rural livelihoods and regional food security. Taro is affected by several fungal and bacterial diseases including the highly destructive leaf blight caused by *Phytophthora colocasiae* Raciborski [5, 6]. The disease affects the leaves, petioles, corms and cormels, and causes heavy yield losses which may exceed 50% in severe cases [7]. Some researchers have reported 50–100% losses in corm yield in some locations where taro is grown in Cameroon [5, 8, 9]. As a result, some farmers have abandoned their taro farms to cultivate other crops. The resulting scarcity has led to exorbitant prices in local markets. The disease has caused a serious decline in production and led to a decrease in food availability and household income, as well as an increase in poverty.

Information is limited on the incidence and severity of leaf blight disease and effective management measures in the taro production areas. Synthetic fungicides have often been used against fungal diseases of plants in the tropics. However, these pesticides are costly and most are extremely toxic to living organisms and the environment. Other methods which have been reported by researchers to manage leaf blight disease include the following: careful selection of planting materials, intercropping taro with other crops and crop rotation [7]. The extracts of several plants have been reported to inhibit the growth of fungal pathogens. These plants include goatweed (*Ageratum conyzoides* L.), neem (*Azadirachta indica* A. Juss.), pawpaw (*Carica papaya* Lam), tobacco (*Nicotiana tabacum* Linn.), goosegrass (*Eleusine indica* (L.) Gaertn.), African teak (*Milicia excelsa* Welw.), African ebony (*Diospyros crassiflora* Hiern.), siam weed (*Chromolaena odorata*) and horseradish tree (*Moringa oleifera)* [10-18]. Plant extracts are easy to prepare and biodegradable. However, information is scarce on their fungicidal effect on *P. colocasiae*.

This research was undertaken to assess the incidence, severity and farmers' knowledge of taro leaf blight disease in different localities in the South West Region of Cameroon and the potency of the aqueous leaf extract of goatweed against the pathogen. Goatweed is a common weed in the study location.

2. Materials and Methods

2.1. Description of Study Sites

Disease surveys were carried out during the rainy season from April to June, 2012 in seven localities in three sub-divisions of Fako Division in the South West Region of Cameroon where taro is commonly cultivated: Buea (Molyko, Bokova, Muea and Mile 16), Tiko (Mutengene and Likomba) and Muyuka (Ekona). The Division is characterized by a humid tropical climate and two seasons: wet and dry.

2.2. Disease Assessment

Surveys were conducted using the non-destructive method to assess the incidence and severity of the disease on-farm. Two farms with established taro plants were selected in each locality, making a total of 14 farms in the study area. In each farm, assessments were made on 20 plants selected at random, following a diagonal pattern from two quadrats, 64 m^2 each. Within each quadrat, observations were recorded from 10 plants; therefore, 40 plants were sampled in each locality. The number of plants with symptoms of the disease was counted and recorded. Disease incidence was determined as the ratio of the number of plants with disease symptoms to the total number of plants assessed and presented as a percentage. Severity was evaluated from the infected area of two fully opened leaves per plant and rated based on the 5-point scale proposed by Omeje, *et al.* [19] where 0 = no infection and 4 = very high infection. The formulae used were as stated below:

$$\text{Disease incidence (\%)} = \frac{\text{Number of infected plants} \times 100}{\text{Total number of plants}}$$

$$\text{Disease severity (\%)} = \frac{\text{Area of leaf infected} \times 100}{\text{Total leaf area}}$$

Leaf area was obtained using the method reported by Adinde, *et al.* [20].

2.3. Assessment of Farmers' Knowledge of the Disease

One hundred and eighty-five farmers in the study area with established taro plants in their farms were selected for the survey. A structured questionnaire was used to obtain information on age, sex, farm size, cropping system, types of cocoyam produced, diseases that affected taro, and the farmers' knowledge of leaf blight disease and the methods which they used for its management.

2.4. Collection of Infected Leaf Samples and Isolation of the Pathogen

Samples of infected taro leaves with visible symptoms of blight disease were collected from the surveyed farms, packed in paper bags and transported to the Life Sciences Laboratories of the University of Buea. The leaf samples were washed with tap water and cut with a blade into 2 cm × 2 cm pieces at the interface between healthy and infected portions. The pieces were surface sterilized for 2 minutes in 1% sodium hypochlorite solution, rinsed in sterile distilled water, and placed on blotting paper to get dry. The pieces were plated on Potato Dextrose Agar (PDA) supplemented with Ampicilin antibiotic, and incubated at room temperature. After five days, tips of the hyphae were transferred to fresh PDA to obtain pure cultures. The fungus was identified using the procedure described by Abdulai, *et al.* [6].

2.5. Assessment of the Aqueous Extract of Goatweed on *P. colocasiae*

Fresh leaves of goatweed, were harvested from fields in Buea and identified at the Botanical Garden in Limbe, South West Region. The leaves were washed with tap water and the aqueous extract (100% concentration) was prepared as reported by Lum, *et al.* [15].

The antifungal effect of the aqueous extract of goatweed was determined using the procedure described by Lum, *et al.* [15]. The extract (100%) was compared with a synthetic fungicide (mancozeb, an ethylene bis-dithiocarbamate with contact action), and a control (with no extract or synthetic fungicide). The treatments were replicated three times and the Petri dishes were placed in a completely randomized design. Radial growth of the fungus was measured at 3, 6 and 9 days after exposure (DAE) using a transparent ruler. Colony diameter was obtained as the mean along two perpendicular lines drawn at the bottom of the Petri dishes prior to incubation. The percentage of inhibition was calculated as described by Lum, *et al.* [15]. The effectiveness of the extract was determined based on the percentage of inhibition. The level of inhibition for the extract was assessed using the following scale: 0% = not effective; >0–25% = slightly effective; >25–50% = moderately effective; >50–<100% = effective; 100% = highly effective.

2.6. Data Analyses

The data collected were subjected to analyses of variance using the Statistical Package for Social Sciences (SPSS, Version 17). Means were separated using Tukey's test at $P<0.05$.

3. Results

3.1. Disease Incidence and Severity

The field survey indicated that taro leaf blight disease was prevalent in Fako Division. The common symptoms observed on infected plants in the farms were: small dark or brown spots on the upper surfaces of the leaves; completely blighted leaves; plants with only a few leaves which were reduced in size; oozing of clear exudates around the leaf margins which appeared water-soaked; brown spots on infected petioles; lodging; and small or rotted corms.

The incidence and severity of leaf blight disease varied significantly ($P \leq 0.05$) among the surveyed localities (Figure 1). In general, the incidence ranged from 77.9 to 96.5%; the highest results were recorded in Mile 16 and Ekona while the lowest were obtained in Bokova. The disease incidence was comparable in the other four localities (mean = 90.4%). The order was Mile 16 = Ekona > Likomba = Molyko = Muea = Mutengene > Bokova.

The disease was most severe in Mile 16, Bokova and Ekona with a mean value of 83.2% and a severity score of 4, indicating a very high infection rate. The infection was less severe (mean = 54.9%) in Mutengene and Likomba with a severity score of 3, still showing a high infection rate. Disease severity was similar in Muea and Molyko (mean = 69.2%), and both locations recorded a score of 3, also indicating a high infection rate.

3.2. Farmers' Knowledge of Taro Leaf Blight Disease

Out of the 185 farmers interviewed, 67 (36%) were males and 118 (64%) were females. Their ages ranged from 18 to >55 years. A total of 78 farmers were >55 years old (34 males and 44 females). All of them depended solely on their farms for livelihood. In general, they were small-scale farmers with farm sizes ranging from 250 to 500 m^2 and the varieties of cocoyam that they commonly cultivated were taro and macabo (*Xanthosoma* spp.). However, they produced more taro than macabo in all the locations (Figure 2). The majority (60%) indicated that they cultivated taro both for sale and home consumption, 2% of them solely for commercial purposes and 38% only for home consumption. Most of the farmers (74%) planted taro in monoculture, 18% of them mixed it with macabo while 8% cultivated macabo alone.

Most of the farmers (88.1%) ranked leaf blight as the major disease which affects the cultivation of taro (Figure 3). The symptoms which they reported consisted of brown spots on the leaves, which enlarged rapidly, followed by rotting that extended to the petioles and the plants could not be consumed; some affected plants also had reduced leaf number and size. The farmers had observed that the disease infected young and old plants leading to very low corm yield or plant death. They also indicated that the disease was more pronounced when the crop was planted in monoculture than in mixed cropping, and the infection rate was more in the rainy season than when it was dry. Although all the farmers could identify the disease, 80% of them did not know the cause while 20% believed that it was caused by acid rain. Other diseases listed by a few farmers were corm rot and root rot; however, farmers in some of the localities did not report them as constraints to taro production. Only 3.3% of the farmers, specifically in Molyko, Bokova, Muea, Mutengene and Likomba indicated that corm rot disease affected taro cultivation. A few respondents (1.6%) in Ekona, Mile 16 and Likomba listed root rot disease.

The farmers used various approaches to manage the disease (Figure 4). The most common were the cultural methods notably the removal of infected leaves, intercropping and application of wood ash. However, they complained that these methods were not effective because the disease had a fast rate of spreading to other leaves within / or between plants. They also reported that the removal of infected leaves was tedious. Up to 35.9% of them did not manage the disease in any way because they were ignorant of what to do. According to them, they preferred to abandon their taro farms and cultivate different crops. Only 10.8% used synthetic pesticides and complained that they were not effective. The last set of farmers (3.3%) stated that they combined the cultural and chemical methods but the disease was still a problem to the crop. None of them used pesticidal plants or botanicals to manage the disease.

3.3. Management of Taro Leaf Blight Disease

The fungicidal effect of the aqueous leaf extract of goatweed at 3, 6 and 9 DAE is presented on Figure 5. The plant extract and synthetic fungicide significantly ($P \leq 0.05$) inhibited the growth of *P. colocasiae* compared to the negative control throughout the period of incubation. The inhibitory effect of the plant extract increased from 3 to 9 DAE. In general, goatweed extract gave moderate inhibition of the fungus (21.0–38.4%). The synthetic fungicide completely inhibited the growth of the fungus throughout the experimental period.

The pathogen had whitish colony with fluffy appearance on the growth medium. The hyphae were aseptate and the sporangia looked hyaline and globose.

4. Discussion

Results of the on-farm surveys revealed that the disease was prevalent across the seven localities sampled in Fako Division. The values for disease incidence (77.9–96.5%) and severity (51.9–85.6%) were generally high although they varied across the locations. The infection rate was high in four localities (Muea, Molyko, Mutengene and Likomba) and very high in three (Mile 16, Bokova and Ekona). These results suggested that location had an influence on the variable levels of infection. This may be because the pathogen can be dispersed from one place to another. Similar observations were also reported in another study carried out in Ghana [6]. The wide distribution of the disease and elevated infection rates recorded in this study confirmed that it is a threat to the sustainable production of taro as stated by other researchers [5, 9, 21].

The common practices carried out in the various localities might have contributed to the high levels of infection recorded as well as the fast rate of disease spread. For instance, taro was mostly planted in monoculture and close spacing; this enhanced dispersal of the pathogen across the fields. In addition, the farmers used planting materials from previous seasons, family members, neighbours, other farmers, and the markets which may not have originated from accredited sources. The continuous cultivation of taro on the same field, for several seasons using the same planting materials could lead to the spread of the infection and low yields. Similar findings were reported by Tarla, *et al.* [22]. It is also possible that spores produced on the taro leaves were easily spread by wind or washed by rain to nearby plants. The study sites were in the humid forest zone characterized by warm and humid climatic conditions which favoured the dispersal of the pathogen. These observations are in line with those of other researchers [6, 9, 19, 23].

The survey indicated that more females were involved in taro production than males and most of them had farms of relatively small sizes. The farmers recognized the disease and understood that high levels of infection could cause complete leaf and corm yield losses. The farmers also indicated that during the rains, the infection rate was higher than when dry. This suggests that seasonal changes affect the incidence and severity of the disease on taro. These findings agree with those of Lin, *et al.* [24], Omeje, *et al.* [19], Otieno, *et al.* [25] and Abdulai, *et al.* [6] who reported high levels of the disease during the wet season. In farms where taro was intercropped with macabo, the disease affected only the taro plants. Although both crops belong to the family Araceae, it is possible that macabo is resistant to the disease. Some of the practices used by the farmers for managing the disease were removal of infected leaves, application of synthetic fungicides and wood ash; but they did not have satisfactory results. In addition to being tedious, roguing was not feasible given the fast rate of disease spread. The synthetic pesticides were costly; given that these were small-scale farmers without adequate resources, it is possible that they could not purchase the fungicides each time there was a need to apply them. However, farmers should not be encouraged to use synthetic pesticides because they cause adverse effects on humans and the environment. None of them reported the use of pesticidal plants.

The *in-vitro* study revealed that the aqueous leaf extract of goatweed at 100% concentration possessed fungicidal properties against mycelial growth of *P. colocasiae*. The inhibitory activity of goatweed leaves could be due to the presence of phytochemicals in them. Amadi, *et al.* [26] reported the presence of several phytochemicals in goatweed such as alkaloids, tannins, flavonoids, saponins, glycosides, phenols and resins. The authors also stated that the large amount of alkaloids and flavonoids in the plant's leaves could be responsible for antimicrobial activity. Javed and Bashir [27] also indicated that goatweed has fungicidal and allelopathic potentials. However, the extract exhibited different levels of antifungal activity against the pathogen at the different periods of incubation. These observations suggest that the inhibitory effect of the plant extract also depends on the period of incubation. Similar observations were reported by Gwa and Ekefan [14] in another study.

5. Conclusions

The findings of this study confirmed that taro is one of the major crops in Fako Division and leaf blight disease caused by *Phytophthora colocasiae* Raciborski is a threat to its production. The disease was widespread in the villages sampled and the level of severity was high. The disease was more severe during the rainy season than when dry. The farmers had adequate knowledge of the disease and its effects on taro production but they were not able to manage it appropriately. A few of them depended on the use of synthetic pesticides which did not yield satisfactory results as they indicated. They had limited knowledge of indigenous methods and/or plant pesticides for management of the disease. The aqueous leaf extract of goatweed at 100% concentration possessed fungicidal properties against mycelial growth of *P. colocasiae*. Plant pesticides would be cheaper and safer than the synthetic pesticides and the farmers would readily adopt them if appropriately formulated for use. Therefore, goatweed and other pesticidal plants should be exploited further for use by resource poor farmers. These results serve as baseline information for further research and contribute significantly to knowledge on the incidence, severity, farmers' perceptions and management of the disease in the major taro-growing areas in Fako Division, South West Region, Cameroon.

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Figure-1. Incidence and Severity of Taro Leaf Blight Disease in Fako Division in 2013

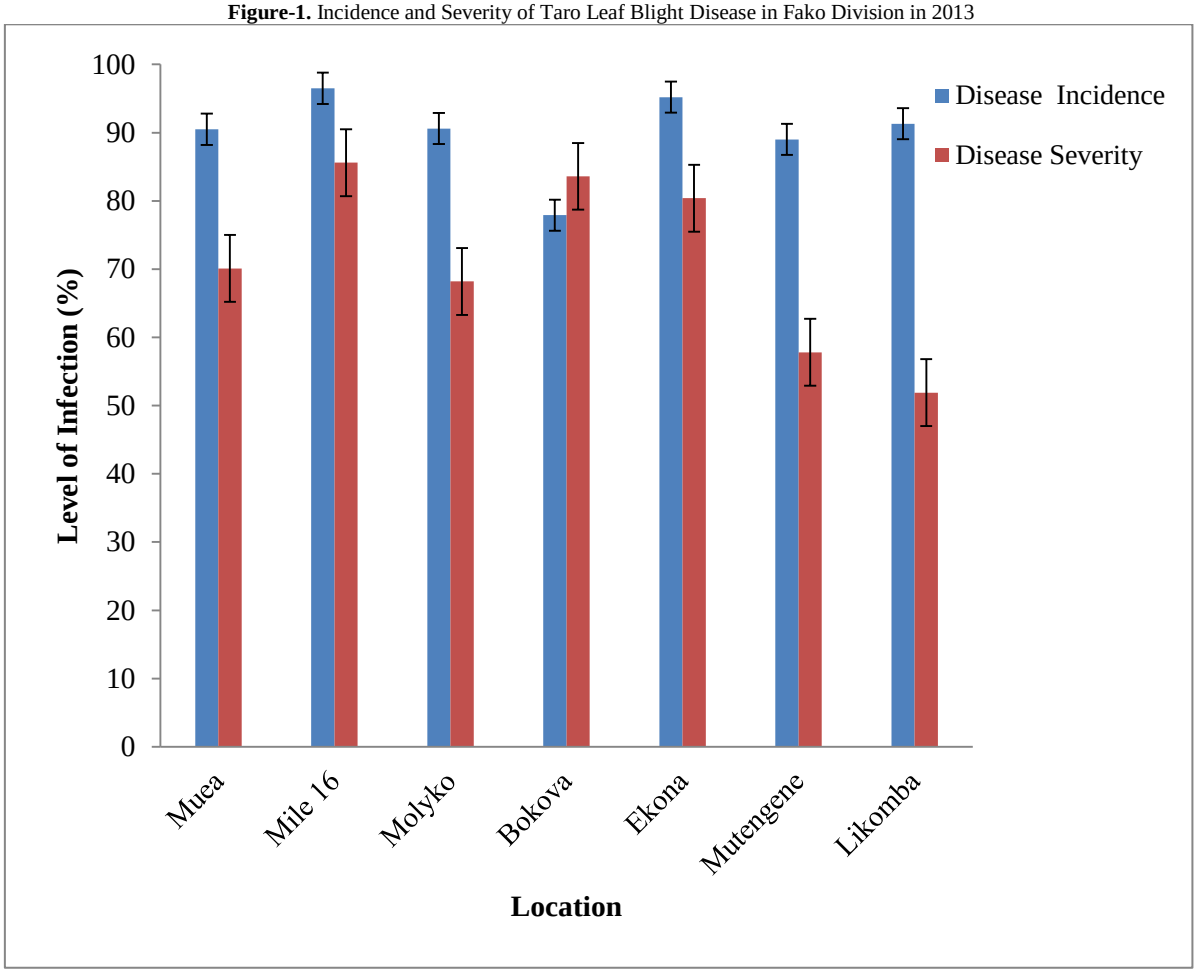

Figure-2. Types of Cocoyam Cultivated by Farmers in Fako Division in 2013

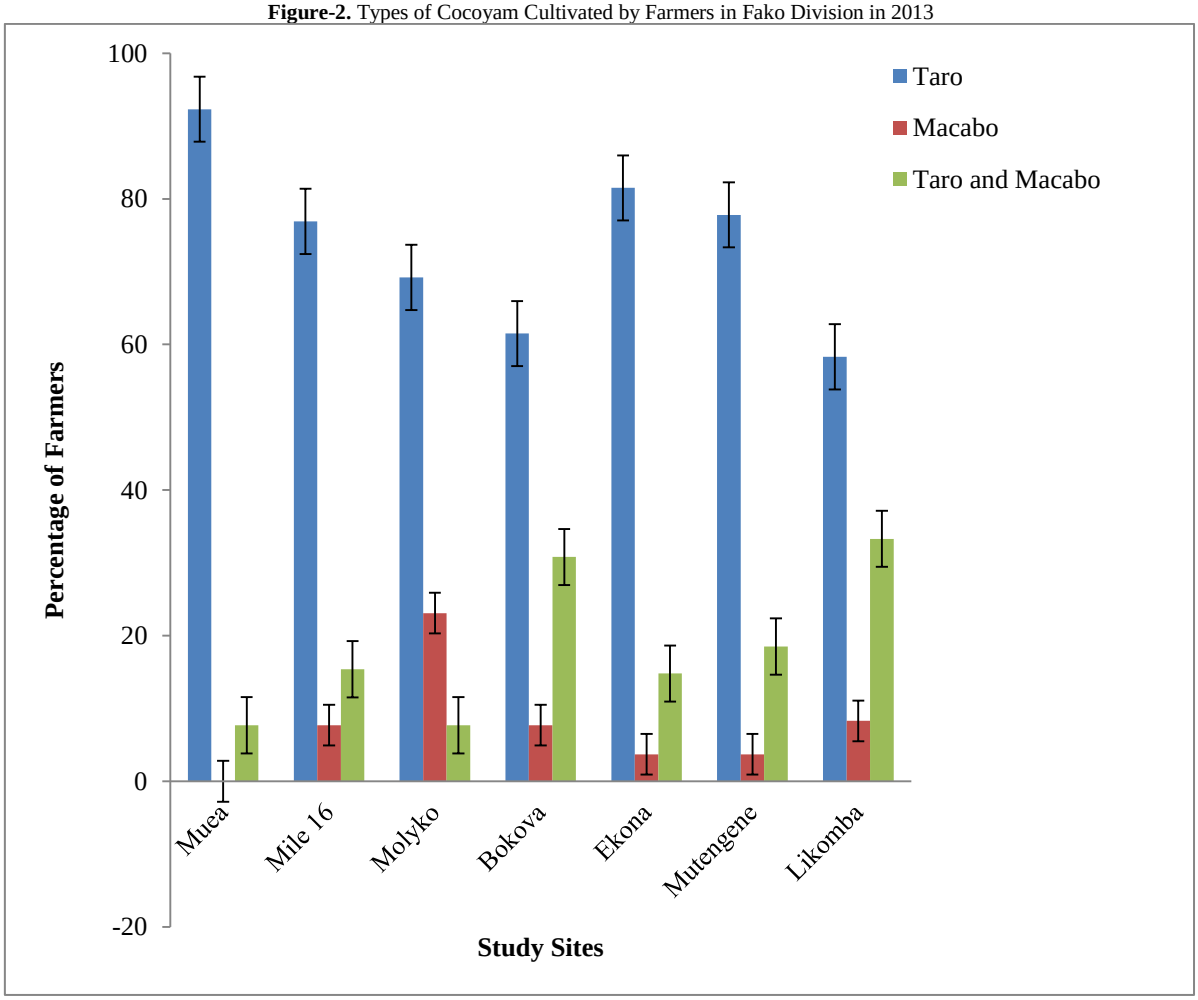

Figure-3. Cocoyam Diseases Listed by Farmers in Fako Division in 2013

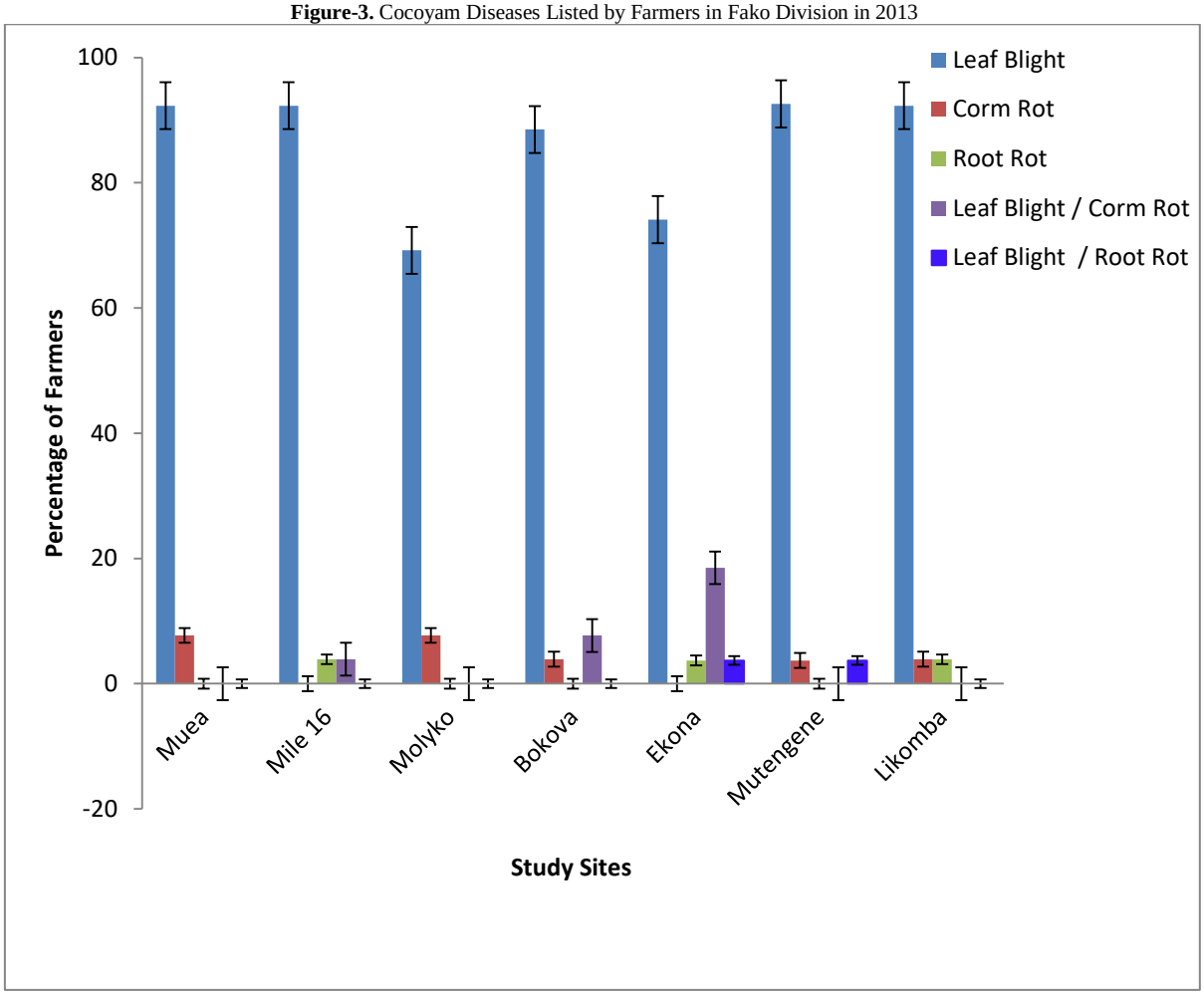

Figure-4. Methods Used to Manage Taro Leaf Blight Disease in Fako Division

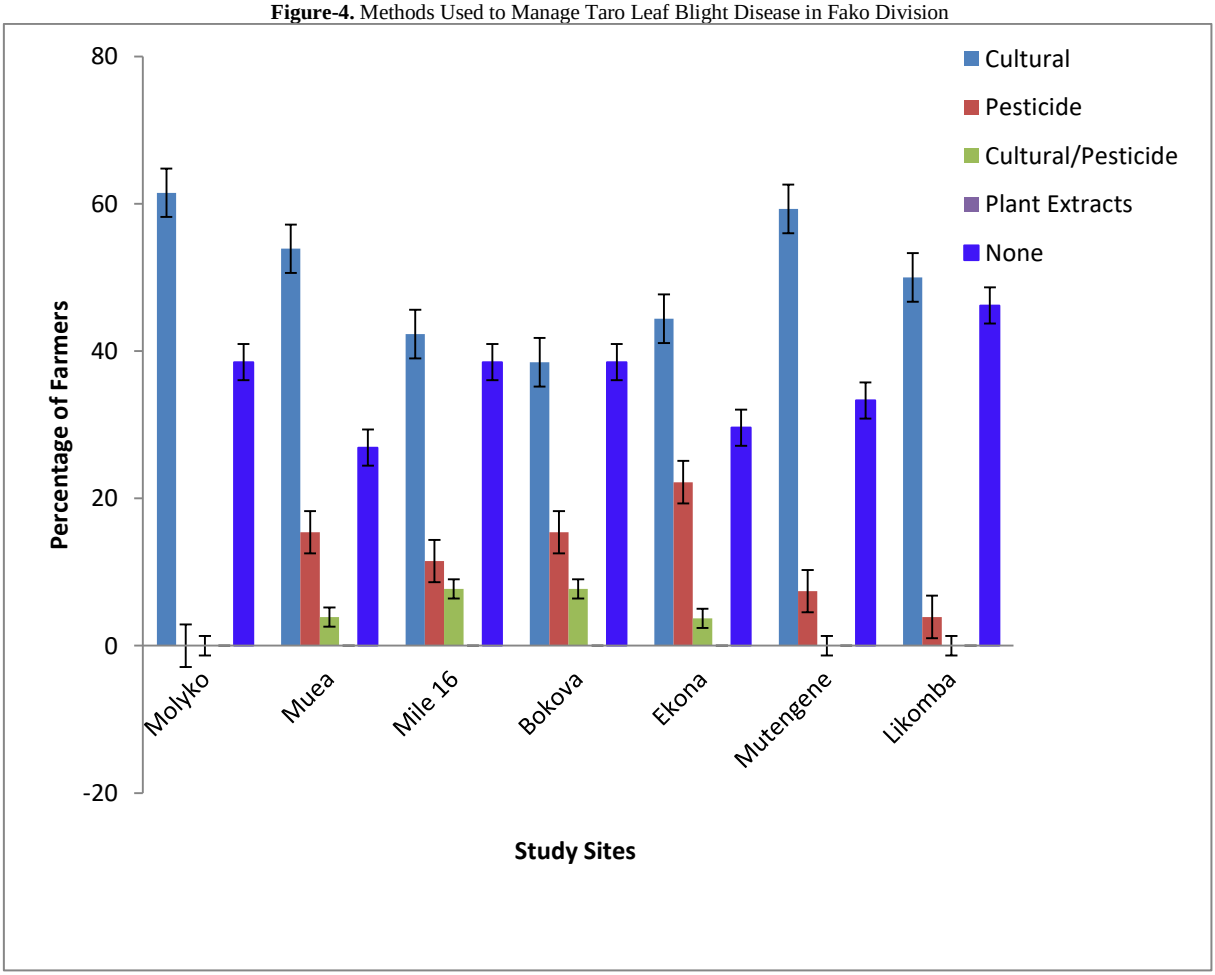

Figure-5. Effect of Aqueous Leaf Extract of Goatweed (100% Concentration) on Mycelial Growth of *Phytophthora colocasiae* at 3, 6 and 9 Days After Exposure