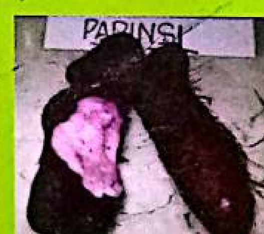
VOLUME 2

FARMING PRACTICES AND FARM ENVIRONMENT AFFECTING INCIDENCE OF INSECT PESTS AND DISEASES ON SWEETPOTATO, TARO AND YAM GROWN BY INDIGENOUS FARMERS IN BENGUET AND NUEVA VIZCAYA, PHILIPPINES









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FOREWORD

The adverse effects of the occurrence of pests and diseases on farmers' livelihood and on the availability and accessibility of food supply always prompts immediately the attention and technical assistance of the academe, the scientists and researchers. The Benguet State University and the Northern Philippines Root Crop Research and Development in particular responded when the yam anthracnose wiped-out credit-assisted yam farms in Tuba, Benguet; when the sweetpotato feathery mottle virus almost diminished the commercial farms in Tarlac; the widespread potato leaf miner infestation in Benguet; and lately, the sweetpotato fusarium wilt damage in Benguet and Nueva Vizcaya.

This research on Rootcrop Diseases Currently Affecting Livelihood and Food Security of Indigenous Farmers in the Highlands of Northern Philippines is in support of current and planned efforts to rehabilitate sweetpotato, yam and taro farms in Benguet, Nueva Vizcaya and elsewhere in the Philippines.

The results of this research will be useful for the local and national agriculture units being tapped to provide mitigation efforts, research and development especially for the many growers of root crops in the Philippines. Furthermore, the results of this research will be an input for the Northern Philippines Root Crops Research and Training Center - Benguet State University in assessing their available technologies like resistant varieties, mass production of clean planting materials, and in directing its research and training programs.

CYNTHIA G. KISWA
Director, NPRCRTC

ACKNOWLEDGMENT

The authors sincerely appreciate the financial assistance provided by the Neys-van Hoogstraten Foundation for the project *PH281- Rootcrop Pests and Diseases Currently Affecting Livelihood and Food Security of Indigenous Farmers in the Highlands of Northern Philippines*, the comments and suggestions of the Technical Committee in the proposal, and progress reports; the willingness of the local government agriculture units especially as key informants and in coordinating the workshop-interviews; and the active participation of the root crop growers and village officials, too many to mention but listed in the appendices, in making this research possible.

Further, the authors also appreciate the Benguet State University administration, especially Dr. Carlito P. Laurean, the Vice President for Research and Extension, for the encouragement, endorsement, approval and recognition of the project as a regular workload of the Northern Philippines Root Crops Research and Training Center.

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EXECUTIVE SUMMARY

This research was conducted because of the reported incidence of insect pests and diseases that decreased yields, and loss of crops and varieties of root crop farmers in the highlands of Northern Philippines. The goal is to complement university and local government mitigation measures of mass producing disease-free planting materials of sweetpotato, yam and taro for distribution to farmers, and other R and D initiatives. The research identified villages and municipalities affected by sweetpotato fusarium wilt, taro leaf blight and beetle, and yam anthracnose; documented incidence and severity of the insect pests and diseases; and its effect on farmers' livelihood and food security of growers in the provinces of Benguet and Nueva Vizcaya.

Data were gathered from primary and secondary sources, key informant interviews, group-interview workshops and focused group discussions followed by farm visits and case study. Data were encoded and analyzed using Excel and the SPSS software.

The sweetpotato insect pests and diseases considered most damaging were sweetpotato fusarium wilt (SPFW) and sweetpotato weevil as observed respectively by 100% and 73% of the growers. SPFW causes yellowing of the lower, older leaves, falling off of leaves and death of stems/vines. Majority of growers (55%) rated the disease as severe. Based on percentage decrease in root yield that ranged from 76-100%, 36% rated the disease as moderate and only 6% rated the disease as mild where decrease in root yield is 25% and below. Almost all (82%) of the growers agreed that root sizes became smaller and percentage decrease in root yield ranged from 25% to 100% because of SPFW disease.

Sweetpotato fusarium wilt was first observed in 2012 by 92-94% of farmers who grew sweetpotato both as cash crop and for home consumption. Rootcrops, rice, vegetables and legumes, and fruits are planted by the sweetpotato growers. Irrespective of area planted to sweetpotato (<500m^2 to 1 ha) in swidden farms (*uma*) or in backyard gardens where sweetpotato is planted as one of the mixed crops; or in paddy fields and vegetable gardens as a monocrop and rotation crop; the sweetpotato crop in Benguet and Nueva Vizcaya were infected by the fusarium wilt disease.

Of the factors affecting the incidence and severity of SPFW, climatic conditions, planting materials and harvesting time showed closer association. Changing climatic conditions had a greater effect on harvesting period than planting time. If planting materials are sourced from previously infected, the probability of SPFW was higher. Other probable causes include cropping system, planting time, varieties and other crops grown. Banana, ginger, taro, tannia, tomato and beans showed symptoms similar to the sweetpotato fusarium wilt. Few (17%) apply inorganic fertilizer and majority (74%) do not use pesticides. Few indigenous sweetpotato varieties were identified by the growers as tolerant to SPFW but sometimes conflicting among the growers because of different reactions of these varieties.

Varieties were considered tolerant because these varieties were able to yield at least 25% of the potential yield despite severe infection of sweetpotato fusarium wilt. Tolerance and susceptibility of these varieties to fusarium wilt may be considered as defense mechanism for disease control.

There are 13 pests affecting taro but taro leaf blight (TLB) and taro beetle (TB) were identified, respectively by 100% and 89% of respondents, as the most damaging. Other diseases and insect pests were rot, rust or *date*, cutworm or *rimas/dimas*, hornworn or *ataro*, white fly and aphid (*aplat*), *white* grub (*hapiloy/balikutkot/loklok*), hopper, snail (*kuhol*), beetle (*tulbing*) and others locally known as *kawaweng/kawatang*, *safidol* (larvae of beetle) and *batungol/arabas/dangaw/shangew* (whiteflies).

One hundred percent of the taro growers observed taro leaf blight incidence and 86% observed taro beetle damaging their crop. More growers rated taro leaf blight incidence as moderate to severe, and taro beetle damage as mild to moderate. Despite the high pest prevalence, most farmers do not employ any means to manage the pests except for those engaged in taro cash crop in which case the application of chemical pesticides is undertaken.

Majority of the growers claimed that corm yield decreased regardless of severity rating because of smaller corms, or poor corm quality and zero yields.

Climatic changes, crop management practices like irrigation, weeding, planting, fertilization, pesticide use, land use, planting materials, varieties and pest management practices are factors that influenced occurrence and severity of TLB and TB.

Anthracnose of yam is one of the growers' greatest challenge in yam production. The severity of infection was recorded at the 4th to 5th month after planting during the wet season planting where plant parts readily attacked include the leaves, vines and leaf base. In assessing severity of the disease, 57% of the growers/respondents rated yam anthracnose disease as mild, 20% as moderate and 23% as severe.

Sixty-nine percent (69%) of the total growers claimed that their yield significantly decreased due to anthracnose infection and only 31% claimed that the anthracnose has no effect on their yield particularly from barangay Basil, Tublay. The percentage decrease in yield highly differed among growers in the different barangays with 2% of growers in Taloy Sur claiming 100% decrease in their yield. Ten percent of the total growers in barangay Bayabas and Taloy Sur however reported 51-75 % decrease in yield. Majority of the growers (51%) claimed to have only 26-50% yield decrease and 25% reported 0-25% decrease in yield.

Multiple infection and insect pest damages was also observed to be affecting the yam crops in the locality. Yam antrhacnose infection was observed by 12% of farmer-respondents in Taloy Norte. Tuber rotting was also noted by 10% of farmers in Taloy Sur and San Pascual.

Only 2% of farmers noted minimal insect pest damages which can be tolerated by the crops until full maturity.

The fungus causing anthracnose disease in yam is widespread in the yam growing areas of Benguet and Nueva Vizcaya especially in the municipalities of Tuba and Sablan. This is a big threat to food security of farmers should favorable weather conditions for the fungus occur. Research and extension services should therefore consider the production of disease-free plant materials which is the foundation of sustainable rootcrop production.

The findings of the case study on taro revealed moderate severity of taro leaf blight. The rating score which is rounded off to 3 indicate that the disease caused 26-50% damage to the crop. To manage this, the case farmer utilise cultural and chemical management measures which include crop rotation, use of taro varieties with resistance to the disease, obtaining planting materials from healthy-looking taro stands and clean source, following the recommended planting distance, proper disposal of infected plants, and, application of fungicide.

The study also documented the insect pests affecting taro from the insect orders namely Spodoptera (cluster caterpillar), Lepidoptera (hornworm), Hemiptera (aphids), Orthoptera (cricket) and Coleoptera (taro beetle and grubs). In terms of infestation/damage caused, most are characterized as low (25% or lesser) to negligible (less than 5%). The most damage was observed to be caused by cluster caterpillar which was assessed at 8-25%.

Analysis of data further showed that there is no correlation between taro leaf blight and armyworm severity and yield.

Results of similar case study on sweetpotato revealed that sweetpotato production was affected not only by biotic factors but also abiotic factors like climate, varietal reaction to insecst pest during the cropping period. Incidence of sweetpotato fusarium wilt was recorded at 3% and was observed on the sixth and seventh month after planting. Insects observed during the cropping season were classified as foliage defoliators with a damage of 51-100% at seven months maturity.

The incidence of insect pests and diseases during the cropping period was affected by climatological factors like rain and humidity. High rainfall and humid conditions affected the canopy cover of the sweetpotato. As a consequence, storage root formation has been affected. The presence of leaf defoliators noted towards the harvest period did not significantly affect root formation hence not considered as economically important.

BACKGROUND INFORMATION

Plant disease reduces the production and quality of food. Losses on the average account for 42% of the production of the six most important food crops. Losses due to postharvest disease can be disastrous, especially when farms are far from markets and infrastructure (Guest, 2012). Crop losses tend to be greatest where knowledge and investments in crop health management are minimal. Low crop yields are common and improved yields/ productivity is vital to increasing food security. One major contributory factor to low yields is crop losses due to plant health problems although the extent attributed to this loss is missing. Yet, crop losses due to plant health issues receive little attention though an important matter of food security (Flood, 2010). The Irish potato famine, the coffee wilt disease in Central and Eastern Africa (Strange and Scott, 2005) and fusarium wilt disease of banana (Vicente and Dita, 2016) are examples that largely devastated livelihoods and food security in the areas affected. In the case of banana fusarium wilt in the Philippines, the disease was confirmed in 2008 which started with 500 cases in 2005 that increased to 15,000 cases in 2007. Only large exporting companies followed the disease control protocol similar to bacterial wilt, i.e., quarantine, sanitation, soil disinfection and fallows (Molina, et al., as cited by Vicente and Dita, 2016).

The increasing pests and diseases problems on root and tuber crops grown traditionally by indigenous peoples in Benguet and Nueva Vizcaya was mentioned in sweetpotato, taro, tannia, greater and lesser yam in 2012 (Gayao, et al., 2013, 2014). However, the assessment of incidence and severity of sweetpotato fusarium wilt, taro leaf blight and taro beetle and yam anthracnose, documentation of background information leading to the disease incidence and its effect on farmers' food production and livelihood were not done.

In 2014, farmers and local government agriculture units requested the assistance of the Northern Philippines Root Crops Research and Training Center (NPRCRTC) and Benguet State University (BSU) to identify and provide mitigating measures to solve the disease problem that wiped out sweetpotato crops. This was confirmed to be fusarium wilt caused by *Fusarium oxysporum* which according to the University Plant Health Clinic, disease incidence increased by 600% in 2015 based on the diagnostic services provided. In response, provision of clean planting materials of tolerant varieties and technical assistance in the establishment of nurseries to multiply clean planting materials for distribution to affected farmers were done. In March 2016, yam seed tubers supplied by traditional yam farmers in Tuba, Benguet were 75% rotten after a month. Damage from these pests and diseases is increasing possibly because of increasing farmed mountain sides and lesser fallow areas. The same is true with the damage caused by taro blight and taro beetle that decreased areas being planted by many small farmers belonging to the indigenous tribes.

In the mountainous *barangay* or villages of Benguet and Nueva Vizcaya, indigenous peoples who traditionally grow sweetpotato, taro, tannia, and yam for their household consumption, also plant these crops as a source of their cash income. The *Kalanguya* farmers in Ambaguio, Nueva Vizcaya can earn PhP30,000 to PhP70,000 per cropping season when they sell their sweetpotato in the Nueva Vizcaya Agricultural Terminal (NVAT) at prices that ranged from PhP15-25 per kilogram (Gayao, et al., 2014). *Ibaloi* farmers in Tuba, Benguet can earn PhP720 to PhP7,840 for each of the roots and tubers planted in a 1000m^2 swidden farm (Gayao, et al., 2013). Whatever is not sold is used for their own food and animal feed. It is not hard to imagine therefore the food insecurity that these small indigenous farmers will face when plant diseases and insect pests will wipe out their crops.

Plant diseases are a threat to food security because it reduces yield and could actually result to total loss of crop. This means reduced or no cash or food supply for the farm household, and may increase external farm inputs. Effect could also be long-term as planting materials and varieties are lost especially for vegetatively-propagated root crops, and the soil becomes infested which affects other susceptible host crops. For small farmers and minor crops, inadequate technical support may aggravate external impacts like poverty, food insecurity, environment degradation and health concerns (Figure 1).

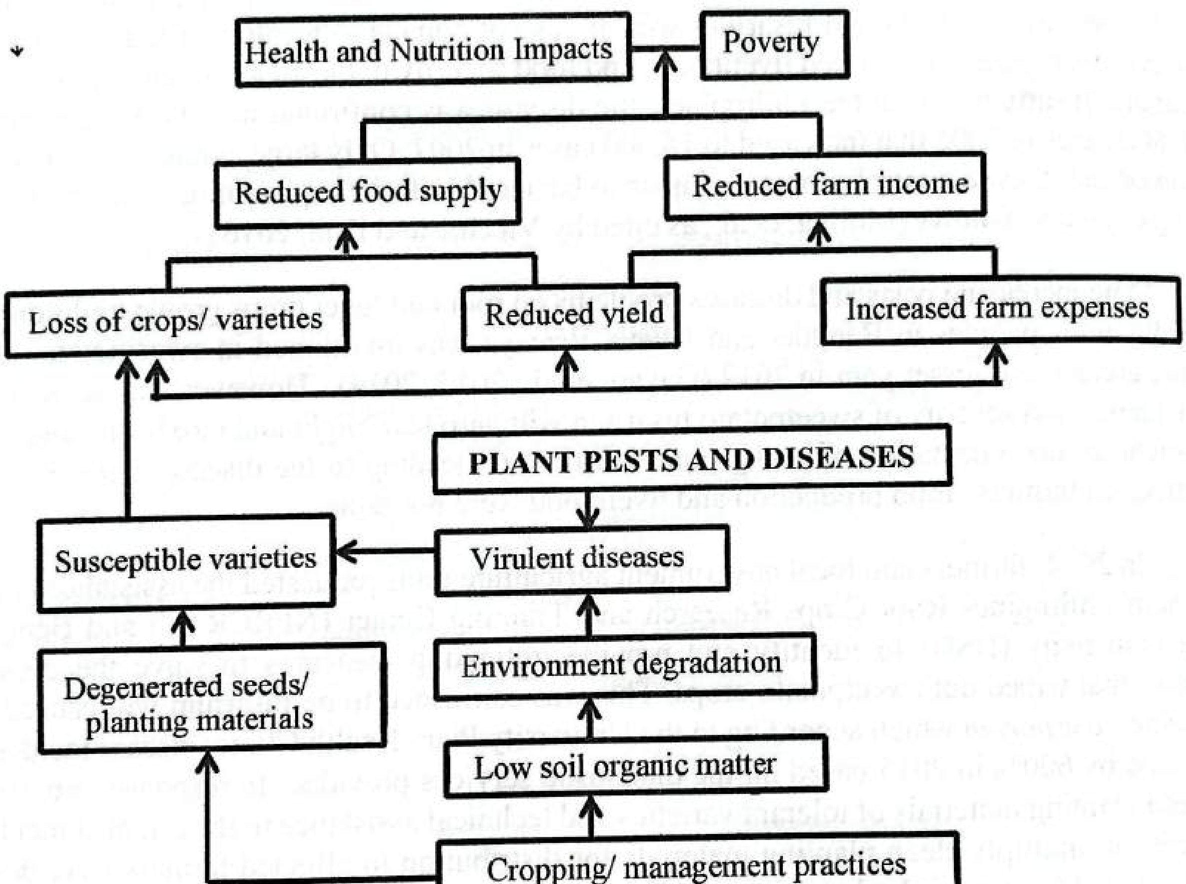

Fig. 1 Causes and consequences of plant disease incidence that may affect food security and livelihood.

Based on Philippines experience, quick response teams coming from the Department of Agriculture, scientists of state colleges and universities, and local government units affected are only activated when there is a rapid and extensive development of a disease. This happens 3-4 years after the disease was observed by farmers. Just like in the banana fusarium wilt, the sweetpotato fusarium wilt was also observed in 2012 and action by mass propagation and dispersal of clean planting materials was started in 2014. There is no systematic monitoring and collection of data on plant health problems especially for root and tuber crops that are only grown in small areas by many small farmers and households. Even for the leaf miner that devastated potato crops in Benguet in 2000 and yam crops in 1992 due to anthracnose disease, there is lack of documents to show the magnitude of food losses due to plant disease.

Hence, this research documented the incidence and severity of sweetpotato fusarium wilt, taro wilt and beetle, yam anthracnose, and its effect on the farmers' livelihood and food security in the locality, farming practices and farm environment, and the farmers' coping mechanisms among root crop growing households and communities in the highlands and hilly lands of Benguet and Nueva Vizcaya, Northern Philippines (Figure 2).

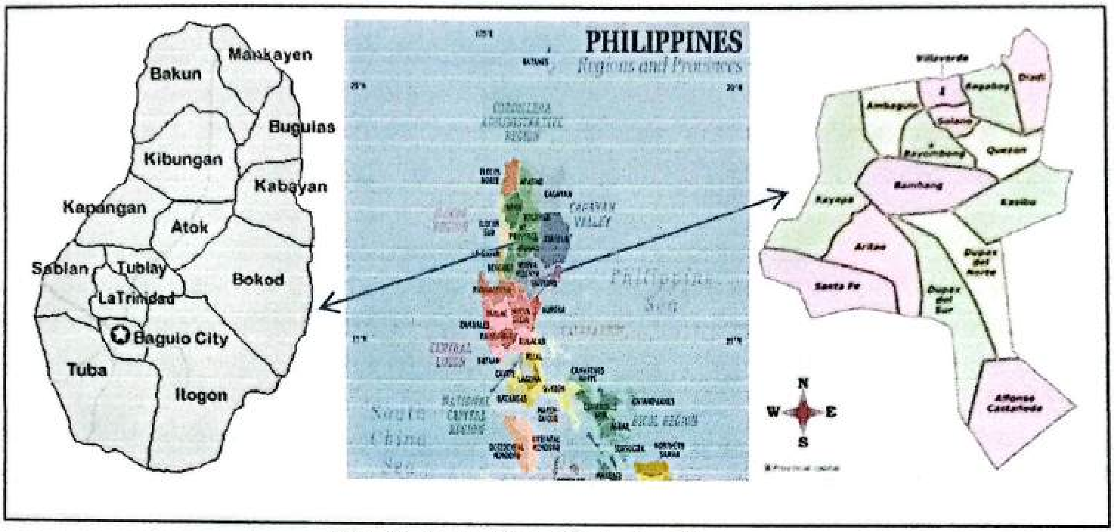

Fig. 2. Location of study sites

This research project report is divided in two volumes. Volume 1 includes the effect of insect pests and diseases on crops/varieties, yield, farm expenses, food supply and farm income. This includes a consolidation of secondary data gathered from information and records of local government offices and key informants (Part 1); Incidence and effect of sweetpotato fusarium wilt (Part 2); Incidence and effect of taro wilt and beetle (Part 3); and Incidence and effect of yam anthracnose (Part 4). Volume 2 includes the farming practices and farm environment; incidence and severity of sweetpotato fusarium wilt, taro leaf blight and taro beetle, and yam anthracnose; other pests and diseases and farmers' coping mechanisms; and, case studies on taro and sweetpotato which aimed to validate the incidence and severity of major diseases and insect pests affecting taro and and sweetpotato.

PART 5

SWEETPOTATO FUSARIUM WILT AND OTHER INSECT PESTS AND DISEASES AFFECTING FARMS OF INDIGENOUS GROWERS IN BENGUET AND NUEVA VIZCAYA, PHILIPPINES

Grace S. Backian, Ammie D. Ngaotoy, Jophr L. Galian and *Betty T. Gayao*

ABSTRACT

This study documented the magnitude of the sweetpotato fusarium wilt infection, its effect on yield and probable causes that include the growers' farming practices, farm environment and other insect pests and diseases in the Provinces of Benguet and Nueva Vizcaya where the disease was first observed in 2012.

Sweetpotato fusarium wilt (SPFW) disease was observed by 92-94% of farmers who grew sweetpotato in swidden farms, in paddy fields, vegetable gardens and backyard gardens. Sweetpotato fusarium wilt and weevil were considered as the most damaging among the 12 sweetpotato insect pests and diseases respectively by 100% and 73% of the growers. Fifty-five percent rated SPFW disease as severe, 36% rated severity as moderate and only 6% rated severity as mild. Almost all of the growers agreed that root yield decreased (<25% to 100%) because of SPFW disease.

Of the factors affecting incidence and severity of SPFW, climatic conditions, planting materials and harvesting time showed closer association (contingency coefficient of 0.500). Other probable causes include cropping system, planting time, use of fertilizer and pesticides, varieties and other crops grown (contingency coefficient of 0.339 to 0.372). Other crops grown like banana, ginger, taro, tannia, tomato and beans also showed disease symptoms similar to the sweetpotato fusarium wilt.

INTRODUCTION

Sweetpotato (*Ipomoea batatas* (L) Lam.) is the sixth most important food crop after rice, wheat, potato, maize and cassava. Likewise, sweetpotato ranks fifth as the most important food crop in developing countries. As much as 105 million metric tons are produced annually and 95% of which are grown in developing countries and Asia is the world's largest sweetpotato producing region (CIP, 2019). In the Philippines, sweetpotato has been a part of the farming systems especially among the indigenous farmers; a food security crop in the olden times; and at present has a very considerable commercial value.

Benguet Province is a primary supplier of vegetable with a share of 86% but sweetpotato still remains as supplementary staple in some remote parts of Benguet. This is so because of its suitability given the mountainous terrain with semi-temperate climate of the area. In Nueva Vizcaya, specifically among the Kalanguyas, sweetpotato is considered as a cash crop because of high market demand. Sweet potato is grown by more than 4,000 growers in the provinces of Benguet and Nueva Vizcaya (Gayao, et al., 2019).

Pests and diseases are the most important constraints to sweetpotato production, yet plant health issues are less noticed. One major contributory factor to low productivity is crop losses due to plant health leading to an estimated annual loss 30-40% from "field to fork" (Flood, 2010). Pest management practices done by farmers are integrated in their cropping pattern and cropping system, however these practices may not be effective enough because of changing climate and other environmental factors that may cause the vulnerability of the sweetpotato crop to pests and diseases.

Fusarium wilt is a pathogenic disease with a very wide host range. The plant and soil-borne fungus is causing wilt in many economically important crops. There are over 120 known strains and each of which is specific to unique host plant in which the fungus causes disease (Tiwari, 2018). Sweetpotato fusarium wilt is considered an emerging disease of sweetpotato crop. This particular disease has been first documented in Ambaguio, Nueva Vizcaya (Gayao, et al., 2014) and later spread to other areas due to the movement of infected planting materials. Sweetpotato fusarium wilt is caused by *Fusarium oxysporum* f.sp. *batatas*. This disease has severely damaged sweetpotato crops particularly in Benguet and Nueva Vizcaya causing an average of 51-100% yield reduction (Gayao et al., 2019). Initial symptoms on sweet potato are interveinal yellowing of the leaves followed by complete yellowing of the lower, older leaves during the rapid growth stage. Leaves later wilt and abscise, stunting results and eventually death of the plant. Necrosis of the stem vascular bundles occurs with brown to purple discoloration; this may be accompanied by rupturing of the cortex of the stem. The vines may turn tan to light brown. Diseased plants may manage to produce storage roots, but these usually have some discolored, infected vascular tissues. Rot may follow in storage or the disease may be transmitted to the next field generation by infected cuttings. Dying vines often have a pinkish fungal growth with numerous macroconidia and microconidia of *F. oxysporum* f.sp. *batatas* (Holliday, 1970; Clark and Moyer, 1988; Thompson, et.al., 2011). Other important sweetpotato insect pests and diseases include stem and tuber feeders, foliage feeders, preharvest and postharvest diseases.

During the survey on indigenous knowledge and the role of root and tuber crops on household food security and income in 2012 the sweetpotato growers brought about their problem of a disease causing wilting and death of sweetpotato crop (Gayao, et. al.). In 2014, the local government agriculture units sought the assistance of the Department of Agriculture and State Colleges and Universities. The disease devastating the sweetpotato crop was confirmed to be fusarium wilt caused by a fungus. Information dissemination on good agricultural practices, clean planting materials production and dispersal and variety screening for resistance to the disease was initiated. However, the magnitude of the disease problem, the extent of losses on yield and probable causes were unknown. At the biological level, the requirements for the speedy and accurate identification of the causal organism, accurate estimates of the severity of disease and its effect on yield, and identification of its virulence mechanisms (Strange and Scott, 2005) was lacking. Hence, this research was conducted to document fusarium wilt incidence and severity in view of the growers' farming practices and farm environment including farmers' coping mechanisms and other insect pests and diseases.

METHODOLOGY

Selection of study sites and respondents

The study was conducted in selected sites of Benguet and Nueva Vizcaya. Selection was based primarily on the secondary data gathered from the municipal local government units which include area planted to sweetpotato and prevalence of sweetpotato fusarium wilt. There were seven municipalities with nine barangays in Benguet and four municipalities composed of 12 barangays in Nueva Vizcaya that were selected as study sites. A total of 132 farmer respondents were interviewed; 86 sweetpotato growers from Benguet and 46 growers from Nueva Vizcaya (Table 1). Majority (79%) of the respondents were female and 21% were male. The males who attended are mostly village or community organization officials and elders. The participation of more female validated the findings of UPWARD that women are more involved in sweetpotato production, marketing and consumption than men.

Table 1. Number of respondents in the selected barangays/municipalities.

PROVINCE/ MUNICIPALITY	BARANGAY	# OF RESPONDENTS		
		Male	Female	Total
BENGUET n,86				
Atok	Naguey		13	13
Kabayan	Tawangan	2	15	17
Kapangan	Sagubo	1	10	11
	Central Kapangan	1		1
Kibungan	Poblacion Kibungan		6	6
	Badeo	3	0	3
Mankayan	Cabiten	2	6	8
Tuba	San Pascual	0	4	4
Tublay	Basil	1	22	23
NUEVA VIZCAYA n,46				
Bambang	Pallas	6	11	17
Kasibu	Cordon	1	9	10
Kayapa	Amelong-Labeng	1	1	2
	Banao	0	1	1
	Cabayo	2	1	3
	Latbang		2	2
	Pinayag	1		1
Sta. Fe	Atbu	2	2	4
	Bantiman	1	0	1
	Buyasyas	2	0	2
	Canabuan	1	0	1
	Poblacion Sta. Fe	1	1	2
TOTAL n,132		**28**	**104**	**132**
%		**21**	**79**	**100**

Data collection

An open-ended questionnaire was prepared as guide to gather the needed information. Data gathered were related to the following: 1) farming system and practices in sweetpotato that may influence occurrence of pests; 2) diseases affecting sweetpotato focused on sweetpotato fusarium wilt incidence and severity, and effect on yield; 3) other insect pests and diseases; 4) local term of insect pests and diseases; 5) farmer's coping mechanism; and laboratory analysis of the diseased sweetpotato samples.

Field Observation and Laboratory Analysis

Farm visit to nearby sweetpotato crop of the participants followed the group interview workshop to validate the incidence of sweetpotato fusarium wilt as observed by the participants. Pictures and samples of affected plants were also gathered. Soil and diseased samples of sweetpotato crop were collected from selected farmer's field in each study site, stored in separate plastic bags and brought to the NPRCRTC Plant Health Clinic for isolation and identification.

Assessment of Fusarium Wilt Severity

Assessment and quantification of plant disease intensity is important information prior to studies on prevention and control of pests and diseases. Intensity is expressed in terms of incidence, i.e., the number or proportion of diseased plants in a population, or the percentage of diseased leaves or stalk in a plant or diseased plants in a field, while severity is the area or proportion or plant tissue that is symptomatic, or the percentage of relevant host tissues or organ damaged by the disease (Campbell and Neher, 1994; Sharma, 2019). In this study however, researchers determined fusarium wilt severity from the point of view of farmer-respondents and as assessed by the researchers using the following formula:

$$\text{Perceived fusarium wilt incidence (\%)} = \frac{\text{Number of farmers who observed fusarium wilt symptoms}}{\text{Total number of sweetpotato growers interviewed}} \times 100$$

$$\text{Fusarium wilt incidence (\%)} = \frac{\text{estimated number of plants/hills with observed infection}}{\text{for every 10 plants/hills of sweetpotato}} \times 100$$

Observation on severity was based by the growers on a scale of 1-5 where (Gayao et. al.,)

Scale	Description
1-2	Mild (75% of the crop was harvested)
3	Moderate (40-60% of the crop was harvested); and,
4-5	Severe (at least 25% of the crop was harvested)

Data analysis

Data gathered were encoded in Excel software and analyzed using the Social Package for Social Sciences (SPSS) software. Descriptive statistics (frequencies and percentages), Pearson chi-square at 5% level of significance and contingency coefficient were used to test significant differences and association.

RESULTS AND DISCUSSION

Characteristics of sweetpotato growers

Sources of cash income. The sweetpotato growers source their cash income either from salary/wages, crop sales, business and other sources like gift from children or as beneficiaries of the Pantawid Pampamilyang Pilipino Program of the government. Differences as to source of income between provinces and among the selected municipalities are highly significant. Crop sales as source of cash income of the indigenous sweetpotato growers in the different municipalities of Benguet and Nueva Vizcaya are highest respectively at 98 and 100 percent. The 100 percent source of cash income from crop sales substantiate the findings of Gayao et al., 2014 that sweetpotato production among indigenous sweetpotato growers in Nueva Vizcaya is primarily for cash income because of high market demand and secondarily as source of food. Sweetpotato is a cash crop in the lowlands like Tarlac Province where the Sweetpotato Regional Center is located.

Table 2. Sources of cash income of sweetpotato growers in Benguet and Nueva Vizcaya

Province/Municipality	Salary/Wages	Crop Sales	Business	Others
Benguet n, 86	**70 (81%)**	**84 (98%)**	**16 (19%)**	**33 (38%)**
Atok	12	13	4	9
Kabayan	14	17	3	7
Kapangan	8	11	3	2
Kibungan	9	9	0	0
Mankayan	4	8	2	6
Tuba	3	4	2	2
Tublay	20	22	2	7
Nueva Vizcaya n,46	**24 (52%)**	**46 (100%)**	**7 (15%)**	**20 (43%)**
Bambang	8	17	5	4
Kasibu	8	10	0	3
Kayapa	5	9	0	7
Sta. Fe	3	10	2	6
Total n, 132	**94**	**130**	**23**	**53**
%	**71**	**98**	**17**	**40**

Multiple response

*x^2 value = 14.13, p .007** between provinces; 75.25, p 0.001***

Description of Sweetpotato Farms

Farmscapes. There were four (4) farmscapes planted to sweetpotato by the indigenous growers in Benguet and Nueva Vizcaya. In Benguet, 76% of the total respondents grow their sweetpotato crop in swidden farms locally called *uma*, 64% in *talon* or paddy fields, 35% in vegetable gardens, and 36% in backyard gardens while in Nueva Vizcaya, most farmers (94%) plant sweetpotato in swidden farms, 54% plant in backyard gardens, 9% in paddy fields, and 15% in vegetable gardens (Table 3). The swidden farm also called slash-and-burn farm or fire-fallow farm are non-permanent since cultivation is only for 2-5 years then fallowed for 3-10 years. Swidden farming is considered an integral method of farming among the sweetpotato growers since several crops are planted. Among the *Kalanguyas* in Ambaguio, Nueva Vizcaya, the *uma* or *inum-an* is so-called if planted to root crops but if planted to cash crop vegetables, it is called garden (Gayao, et al., 2014) and oftentimes no longer fallowed. Differences between provinces and municipalities as to the kinds of sweetpotato farm are highly significant.

Table 3. Farmscapes planted to sweetpotato in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	FARMSCAPES			
	UMA/SWIDDEN	TALON/RICE FIELD	GARDEN	BACKYARD GARDEN
Benguet n,86	65 (76%)	55 (64%)	30 (35%)	31(36%)
Atok	12	0	8	10
Kabayan	10	8	7	5
Kapangan	3	2	3	9
Kibungan	9	0	5	0
Mankayan	6	5	1	1
Tuba	4	1	0	1
Tublay	21	3	6	5
Nueva Vizcaya n,46	43 (94%)	4 (9%)	7 (15%)	25 (54%)
Bambang	16	1	2	8
Kasibu	9	1	5	0
Kayapa	9	1	0	8
Sta. Fe	9	1	0	9
Total n, 132	**108**	**59**	**37**	**56**
%	**82**	**45**	**28**	**42**

**multiple response*

*x^2value= 35.070, p.000** (province);1.643E2, p.000** (municipality)*

Kayapa, Nueva Vizcaya (*uma*/swidden farm)

Sagubo, Kapangan, Benguet (*uma*/swidden farm)

Pallas, Bambang, Nueva Vizcaya (*uma*/swidden farm)

Farm size. Sweetpotato growing households in Nueva Vizcaya operate wider farm sizes than the growers from Benguet. As shown in Table 4, most (28%) of the sweetpotato growers in Benguet farm 500m^2 and below, followed by those farming 1000m^2 to 0.5ha (24%), then those farming 500-1000m^2 (20%) and the rest farm more than 0.5-1ha (13%) and greater than one hectare (15%). In Nueva Vizcaya, most (43%) sweetpotato growers farm 1000m^2 to 0.5ha of land area, followed by those farming 0.5-1.0 ha (26%), and those planting greater than one hectare (24%). Very few (4%) are cultivating only 500m^2 and below. However, average area planted specifically to the sweetpotato crop ranges from 244-471 m^2 in Benguet and 475-579 m^2 in Nueva Vizcaya (Gayao et. al., Vol.1 2019).

Table 4. Total farm sizes planted to sweetpotato and other crops by growers in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	500m^2 & BELOW	>500 TO 1000m^2	>1000 TO 0.5HA	>0.5HA TO 1 HA	>1 HA
Benguet n,86	**24 (28%)**	**17 (20%)**	**21 (24%)**	**11 (13%)**	**13 (15%)**
Atok	9	3	1	0	0
Kabayan	3	0	7	5	2
Kapangan	4	0	2	3	3
Kibungan	1	8	0	0	0
Mankayan	1	1	1	2	3
Tuba	0	0	1	0	3
Tublay	6	5	9	1	2
Nueva Vizcaya n,46	**2 (4%)**	**1 (2%)**	**20 (43%)**	**12 (26%)**	**11 (24%)**
Bambang	0	0	12	4	1
Kasibu	0	0	1	1	8
Kayapa	0	0	1	6	2
Santa Fe	2	1	6	1	0
Total n, 132	**26**	**18**	**41**	**23**	**24**
%	**20**	**14**	**31**	**17**	**18**

**multiple response*

*x^2value= 17.245, p.002** (province);94.107, p.000** (municipality)*

Purpose of planting sweetpotato. Sweetpotato is grown purposely as a subsistence or survival crop. In Benguet and in Nueva Vizcaya, sweetpotato is grown primarily both for family consumption and sale as claimed by 92-94% of the grower-respondents (Table 5) although more growers in Nueva Vizcaya treat sweetpotato as a cash crop. Sweetpotato production is also grown for feed and as give aways. Surprisingly only one farmer in Nueva Vizcaya claimed to grow sweetpotato for planting material purposes. The others depend on their previously harvested crop. This is an indication of a poor seed system for quality planting materials production as disease-free planting material is a preventive measure for pests and diseases occurrence.

Table 5. Purpose of planting sweetpotato among farm households in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	PURPOSE				
	SALE	FOOD	FEED	GIVEAWAYS	PLANTING MATERIAL
Benguet n,86	79 (92%)	82 (95%)	25 (29%)	3(4%)	
Atok	9	12	7	2	
Kabayan	17	17	2	0	
Kapangan	12	12	4	0	
Kibungan	9	8	3	0	
Mankayan	8	7	5	0	
Tuba	2	4	1	1	
Tublay	22	22	3	0	
Nueva Vizcaya n,46	43 (93%)	42 (91%)	18 (39%)	2 (4%)	1(2%)
Bambang	17	15	7	1	0
Kasibu	8	9	5	1	1
Kayapa	9	9	0	0	0
Sta. Fe	9	9	6	0	0
Total n,132	**122**	**124**	**43**	**5**	**1**
%	**92**	**94**	**33**	**4**	**1**

**multiple response*

x^2 value= 6.785, p.452^{ns}; 69.681, p.028 (municipality)*

Cropping system/pattern. Sweetpotato, a versatile crop used as food, feed and raw material for industries has the ability to adjust in any cropping system (Nedunchezhiyan, 2012). The indigenous sweetpotato growers in Benguet and Nueva Vizcaya consider sweetpotato as only one of the mixed crops as claimed by 49% of the respondents, planted in any part of their whole farm as a mono crop (50%), either as a main crop or rotation crop (52%), intercrop (24%) or as border crop (19%) as shown in Table 6. Mixed cropping is a practice done by the indigenous sweetpotato growers of cultivating two or more crops simultaneously on the same piece of land in a definite pattern. By planting multiple crops, farmers can maximize land use while reducing the risks associated with single crop failure. The diversity of crops creates biodiversity, which attracts a variety of beneficial and predatory insects to minimize pests and can also increase soil organic matter, fumigate the soil, suppress weed growth and avoids the susceptibility of monocultures to disease. As a rotation crop, sweetpotato is grown after rice or after a cash vegetable crop to make use of residual fertilizer or to prevent weed growth and maximize use of land. Crop rotation builds better soil structure and increases the ability to store carbon on farms, designed to preserve the productive capacity of the soil, minimize pests and diseases, reduce chemical use, and manage nutrient requirements. The practice of crop rotation can reduce the incidence of wilt but might not be very effective, because the chlamydospores which are the thick-walled large resting spore of several kinds of fungi are long lived and thus many crops are infected without symptoms.

Table 6. Cropping system and cropping pattern practiced by sweetpotato growers in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	CROPPING SYSTEM		CROPPING PATTERN		
	Mono-cropping	Mixed cropping	Main/ rotation crop	Intercrop	Border Crop
Benguet n,86	**41 (48%)**	**44 (51%)**	**47 (55%)**	**29 (34%)**	**19 (22%)**
Atok	9	4	12	1	0
Kabayan	9	8	7	0	10
Kapangan	3	8	4	1	1
Kibungan	9	0	5	4	4
Mankayan	4	4	4	1	3
Tuba	1	3	11	3	0
Tublay	6	17	4	19	1
Nueva Vizcaya n,46	**25 (54%)**	**21 (46%)**	**22 (71%)**	**3 (10%)**	**6 (19%)**
Bambang	8	9	10	2	1
Kasibu	5	5	2	0	2
Kayapa	5	4	9	0	0
Santa Fe	7	3	1	1	3
Total n,132	**66**	**65**	**69**	**32**	**25**
%	**50**	**49**	**52**	**24**	**19**

**multiple response (less 7 in Benguet and 15 in Nueva Vizcaya with no specific cropping pattern)*
*x^2value= 10.430, p.005**; 78.622, p.000** (cropping system)*
*x^2value= 8.980, p.062^{ns};75.3187, p.000** (cropping pattern*

Cropping system has influence on the severity of fusarium wilt (Table 7). The farmer respondents claimed that when they plant sweetpotato as a monocrop, incidence of fusarium wilt is severe. Planting the same crop in succession or a crop from the same family constitutes monocropping and this practice provides the pathogen a perpetually available food source. The increase in pathogen population increases the inoculum reservoir in the soil and eventually results to increased severity. Monocropping of sweetpotato may have aggravated the presence of sweetpotato fusarium wilt. Other crops planted are also host of fusarium wilt like legumes (beans, peanut), vegetables (tomato, eggplant).

Table 7. Influence of cropping system in the severity of fusarium wilt

CROPPING SYSTEM	NUMBER OF FARMERS FUSARIUM WILT SEVERITY			TOTAL (%)
	MILD	MODERATE	SEVERE	
Monocropping	5	16	36	57 (46%)
Mixed cropping	2	25	29	56 (45%)
Combination of mono and mixed cropping	0	1	11	12 (10%)
TOTAL	**7**	**42**	**76**	**125**

Crops planted. In all the municipalities of Benguet (Atok, Kabayan, Kapangan, Kibungan, Mankayan, Tuba, Tublay) and Nueva Vizcaya (Bambang, Kasibu, Kayapa, Santa Fe), rootcrops which include sweetpotato and vegetables are planted in the *uma* or swidden farm. Seed legume is only planted in Kapangan and Kasibu, upland rice only in Kibungan and fruits only in Benguet (Table 8). In *talon* and gardens (including those in backyards), rootcrops and vegetables are also planted. Rice is planted in paddy farms in Atok, with fruits and seed legumes in some gardens and backyards in Benguet. Planting of fruits were not mentioned by respondents in Nueva Vizcaya but maybe included in other crops which include fruit trees like banana, lemon and pineapple, spices, sugar cane and tiger grass (Gayao et. al., 2019).

Table 8. Crops planted in the different farmscapes in Benguet and Nueva Vizcaya

FARMSCAPES/ CROPS	BENGUET n,7*	NUEVA VIZCAYA n,4**
	% of municipality	
Uma/ Swidden		
Rootcrops	100	100
Rice	*(Kibungan)* 14	
Vegetables	71	100
Legumes	*(Kapangan)* 14	*(Kasibu)* 25
Fruits	43	
Other crops	86	100
Talon/ Garden		
Rootcrops	71	100
Rice	*(Atok)* 14	
Vegetables	71	75
Fruits	43	
Other crops	71	100
Backyard Garden		
Rootcrops	71	75
Vegetables	57	75
Legumes	14	
Fruits	43	
Other crops	71	75

**Benguet (Atok, Kabayan, Kapangan, Kibungan, Mankayan, Tuba, Tublay)*
***Nueva Vizcaya (Bambang, Kasibu, Kayapa, Santa Fe)*

Sweetpotato Insect Pests and Diseases

Sweetpotato fusarium wilt (SPFW) incidence was observed by all of the 132 respondents in their farms. The sweetpotato weevil was observed by 73% of the growers where 43% of the sweetpotato growers considered damage as severe. *Igges*, a general term for insect damage which may include leaf hopper, leaf folder, leaf miner and even weevil was also observed by more than 32% but only 3-4% of the growers consider them most damaging (Table 8). Some of these pests were also identified by Ames, et al. (1996) as major pests of sweetpotato (Table 9).

Table 9. Insect pests and diseases affecting sweetpotato crops in Benguet and Nueva Vizcaya

INSECT PESTS AND DISEASES		INCIDENCE	
COMMON NAME	LOCAL NAME	#	%
Fusarium wilt	*Dappog**, *natungro*	132	100
Weevil	*Balitungeg/ Binatungal**	69	73
	*Igges/Arabas/Nabigih**	34	36
Leaf hopper	*Balangaw**	30	32
Leaf folder	*Kubot, Kudkudong*	16	17
	*Tuko**	11	12
Leafminer		4	4
White fly	*Bangao*	4	4
Lady bug		3	3
Army worm	*Kadang-kadang*	1	1
White Grub		1	1
Stem borer		1	1

**Considered with severe incidence are fusarium wilt (100%), weevil (43%), tuko (12%), igges and leaf hopper (3-4%)*
n=132

Figure 1. (a) pupa of stem borer; (b) sweetpotato scab; (c) sweetpotato roots severely infested with sweetpotato weevil.

Sweetpotato Fusarium Wilt

Description. Stem rot or fusarium wilt of sweetpotato (*Ipomoea batatas* (L.) Lam. is an important disease caused by the fungus *Fusarium oxysporum* f. sp. *batatas.* The fungus is soil-borne specific to sweetpotato and can survive in the soil for several years. This is why farmers still experience the fusarium wilt even if they clean the area and use clean planting materials. The pathogen can survive in the soil and in debris for several years. Initial symptoms on sweet potato are yellowing of the lower, older leaves during the rapid growth stage leading to growth retardation, falling off of leaves and stems/vines and eventually death of the plant. Farmers' description is that plant base becomes black, leaves turn yellow until plant dies. These are the symptoms observed in *dappog* among the Ambaguio, Nueva Vizcaya sweetpotato farmers (Gayao, Meldoz and Backian, 2014). Necrosis of the stem vascular bundles occurs with brown to purple discoloration; this may be accompanied by rupturing of the cortex of the stem. The vines may turn tan to light brown (Fig. 2). This disease is also termed locally as *tunglo*, *tungro*, blackleg, *kubot*, *tungba.* Nematodes was also present in sweetpotato roots collected in Sagubo, Kapangan, Benguet. Mechanical wounding caused by nematodes is an important factor in providing avenues of entry for the fungus. Nematode attacks of sweetpotato cause stunting, yellowing of foliage, abnormal flower production, round to spindle-shaped swellings (galls), necrotic root systems and low yields (Mwanga and Fuentes, 2006).

The diseased plants may manage to produce storage roots, but these usually have some discolored, infected vascular tissues. Rot may follow in storage or the disease may be transmitted to the next field generation by infected cuttings. Dying vines often have a pinkish fungal growth with numerous macroconidia and microconidia of *F. oxysporum* f.sp. *batatas* (Holliday, 1970; Clark and Moyer, 1988; Thompson, et.al., 2011, Ames, et al., 1996). This is why farmers still experience the fusarium wilt even if they clean the area and use clean planting materials.

Fig. 2. (a) fungal spores of fusarium, (b) interveinal yellowing of the older leaves, (c) necrosis of the vascular bundles with brown to tan discoloration

Plant parts affected. According to the sweetpotato growers in Benguet and Nueva Vizcaya, the vines, leaves and base of the vines are the most affected parts with only 11% claiming that the whole plant is infected (Table 10). This is the reason why some of the growers are hopeful that the crop will recover and serve as a future source of planting material. However, this is not a guarantee that SPFW disease is eradicated.

Symptoms of infection usually appear on the leaves and vines especially the base part as experienced by most farmers in Benguet (42%). Farmer-respondents (46%) in Nueva Vizcaya claimed that symptoms appear at the vines particularly at the base part (Table 9). Early symptoms of sweetpotato fusarium wilt is girdling of the stem base that usually leads to yellowing of the older leaves first. When the whole plant is affected as experienced by the farmers in Kayapa, Nueva Vizcaya, the plant may show dwarfing, early senescence and eventually death of the whole plant.

Table 10. Parts of sweetpotato plant with symptoms of fusarium wilt in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	PLANT PARTS			
	VINES/BASE	LEAVES	VINES/LEAVES /BASE	WHOLE PLANT
	# of farmers			
Benguet n, 86	**36 (42%)**	**5 (6%)**	**40 (47%)**	**5 (6%)**
Atok	4	2	5	2
Kabayan	2	1	14	0
Kapangan	9	0	3	0
Kibungan	5	0	4	0
Mankayan	3	0	3	0
Tuba	0	1	3	2
Tublay	13	0	8	1
Nueva Vizcaya n,46	**21 (46%)**	**7 (15%)**	**8 (17%)**	**10 (22%)**
Bambang	17	0	0	0
Kasibu	2	0	7	1
Kayapa	0	0	0	9
Sta. Fe	2	7	1	0
Total n, 132	**57**	**12**	**48**	**15**
%	**43**	**9**	**36**	**11**

Multiple response
*x^2 value=23.835^a, p.013** (province)*
*x^2 value=384.12^a, p.000** (municipal)*

Plant growth stage when symptoms appeared. Majority of the indigenous sweetpotato growers claimed that their sweetpotato crop matures from 3.5 to 7 months and sometimes dependent on the variety and climate. According to Nedunchezhiyan and Ray, 2009, there are three phases: 1) planting to root formation; 2) maximum leaf development; and 3) the total development or maturity of roots.

According to 73% of the farmer respondents in Benguet (Table 11), sweetpotato fusarium wilt occurs when their sweetpotato crop is 2-3 months old as further claimed by the sweetpotato growers in the municipality of Tublay and Atok (17 and 16 percent, respectively). This could mean that their sweetpotato crop were able to produce storage roots but have decreased in yield by producing smaller storage roots. This further means that the optimum root yield was not attained because of fusarium wilt. Only 2% in Benguet, particularly in the municipality of Kapangan claimed that sweetpotato fusarium wilt appeared or were observed 3-4 months after planting (MAP) (Table 10). In susceptible varieties like the *Immitlog*, fusarium wilt occurs 38 days after planting (Galian, 2018).

Table 11. Plant growth stage of infection in selected municipalities in Benguet and Nueva Vizcaya

PROVINCE/MUNICIPALITY	GROWTH STAGE			
	</>1 month	**2 to 3 months**	**3-4 months**	**At harvest**
Benguet n,81	**16 (20%)**	**59 (73%)**	**2 (2%)**	**4 (5%)**
Atok	0	13 (16%)	0	0
Kabayan	1	9	0	2
Kapangan	0	10	2	0
Kibungan	5	4	0	0
Mankayan	3	5	0	0
Tuba	0	4	0	0
Tublay	7	14 (17%)	0	2
Nueva Vizcaya n,46	**25 (54%)**	**19 (41%)**	**0**	**2 (4%)**
Bambang	16	1	0	0
Kasibu	0	8	0	2
Kayapa	9	0	0	0
Sta. Fe	0	10	0	0

Stage when symptoms appeared. Majority (59%) of the growers had observed that the fusarium wilt symptoms appeared at 2-3 months after planting (MAP), sometimes earlier at one MAP or less (35%) mostly in the vines and base of the plant, and the other growers only observed the symptoms at harvest (4%) and at 3-4 MAP (2%) (Table 12).

Table 12. Stage when fusarium wilt symptoms appeared in the different parts of the sweetpotato plant

STAGE	PARTS				TOTAL	%
	VINES/BASE	**LEAVES**	**VINES/ LEAVES/BASE**	**WHOLE PLANT**		
	# of growers					
</>1 MAP	26	0	4	11	**41**	**35**
2-3 MAP	22	11	32	5	**70**	**59**
3-4 MAP	1	0	1	0	**2**	**2**
At harvest	3	0	2	0	**5**	**4**

x^2 value, 55.332^a, p.118^{ns}

Percent incidence and severity. More of the sweetpotato growers (17 + 37= 54%) especially in Kapangan, Kibungan and Tublay in Benguet; and Kayapa and Santa Fe in Nueva Vizcaya, estimated a higher percentage incidence of SPFW (Table 13). Consequently, majority of growers (55%) rated severity of the disease as severe based on percentage decrease in root yield that ranged from 76-100% (Table 12); 39% rated severity as moderate and only 6% rated severity as mild where decrease in root yield is 25% and below. Percent incidence and severity highly differed among growers in different municipalities.

Table 13. Incidence and severity of sweetpotato fusarium wilt in selected municiplaities in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	% INCIDENCE				SEVERITY RATING		
	1-25	26-50	51-75	76-100	MILD	MODERATE	SEVERE
Atok	1	4	6	2	2	2	9
Kabayan	0	9	1	6	0	11	6
Kapangan	0	3	4	5	0	7	5
Kibungan	0	0	5	4	0	0	9
Mankayan	0	5	0	3	0	2	6
Tuba	2	1	0	1	0	1	3
Tublay	0	9	5	9	0	9	14
Bambang	3	10	1	1	2	13	2
Kasibu	2	5	0	3	3	4	3
Kayapa	0	1	0	8	0	1	8
Sta. Fe	1	2	0	7	1	2	7
TOTAL n,132	**9**	**49**	**22**	**49**	**8**	**52**	**72**
%	**7**	**37**	**17**	**37**	**6**	**39**	**55**

-province *0.539 p.0.652ns-municipality* *32.24, p.000***

Effect on yield. Almost all (82%) of the growers agreed that root yield decreased or that root sizes became smaller because of SPFW disease (Table 14). Percentage decrease in root yield which ranged from less than 25% to 100% differed significantly among the growers in the different municipalities. A farmer in Tublay, Benguet, felt a decrease of 60% in her harvest or from 50kg to only 20kg after the incidence of sweetpotato fusarium wilt.

Table 14. Change and percentage decrease in yield of sweetpotato planted due to sweetpotato fusarium wilt infection

Province/ Municipality	Zero yield	Decreased yield/ small roots	Percentage Decrease			
			25 & less	26-50	51-75	76-100
Benguet n,86	**21 (24)**	**65(76)**	**7(8)**	**29 (34)**	**36 (49)**	**14 (16)**
Atok	2	11		10	1	2
Kabayan	5	12	1	2	9	5
Kapangan	3	9		1	11	
Kibungan		9			8	1
Mankayan		8	2	2		4
Tuba	2	2	2	2		
Tublay	9	14	2	12	7	2
Nueva Vizcaya n,46	**3 (6)**	**43 (93)**	**1 (2)**	**1 (2)**	**3 (7)**	**41 (89)**
Bambang		17	0	0	0	17
Kasibu	3	7	1	0	3	6
Kayapa		9	0	1	0	8
Santa Fe		10	0	0	0	10
Total n,132	**24**	**108**	**8**	**30**	**39**	**55**
%	**18**	**82**	**6**	**23**	**30**	**42**

x^2 value *73.94* *p-value* *.000****

Factors Affecting Incidence and Severity of Sweetpotato Fusarium Wilt

Climate. Fusarium wilt disease is present regardless of season (Table 15), dry months (25%) or wet months (22%). Climate change, which according to the farmer/growers is the significant rise in temperature and the change of pattern in rainfall from light to heavy, was the predominant condition (35%) that contributed to the appearance or incidence of sweetpotato fusarium wilt. Development of Fusarium oxysporum disease is favored by high temperatures and warm moist soil (Agrios, 1977). According to the farmer-growers, SPFW is visible or severe whenever there is a sudden change in weather just like what was experienced in 2012. It was this time when sweetpotato fusarium wilt almost wiped out the sweetpotato crop of the farmer-growers in Kayapa, Nueva Vizcaya. Pest outbreaks often coincide with climatic changes such as irregular rainfall, increased humidity and drought, and may have devastating impact in a given year, but cause only marginal losses in other years (Pinstrup-Andersen, 2001).

Table 15. Association of climatic conditions to occurrence of sweetpotato fusarium wilt in Benguet and Nueva Vizcaya

CLIMATIC CONDITION	FUSARIUM WILT SEVERITY					Total	%
	MILD		MODERATE	SEVERE			
	1	2	3	4	5		
Cool climate	2	0	5	0	3	**10**	**9**
Dry months	3	1	9	1	11	**25**	**23**
Wet months/ rains	2	2	3	0	15	**22**	**21**
Rapid change in weather	0	0	9	1	5	**15**	**14**
Climate change	2	3	11	2	17	**35**	**33**
Total	**9**	**6**	**40**	**8**	**56**	**107**	**100**
%	**8**	**6**	**37**	**7**	**52**		

x^2 value=52.291, p.09[2ns]

Note: 25 respondents has no response

Planting/ harvest time. In Benguet, 33% of the respondent's plant during wet months (April to October) or dry months (November to April) and 31% of the total respondents claimed that planting can either be during the dry months or wet months (Table 16). However, Kibungan sweetpotato farmers plant during the wet months only because their sweetpotato is planted after upland rice. In Nueva Vizcaya, respondents from Bambang plant their sweetpotatoes only during wet season while the sweetpotato growers in Kayapa plant during the dry months. Cultivation of sweetpotato during the wet months results in a longer age and lower root production because sweetpotato plants will have a long vegetative growth phase, (Widaryanto and Saitama, 2017).

Table 16. Planting and harvest season of sweetpotato in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	PLANTING SEASON			HARVEST SEASON		
	Wet	Dry	Wet/Dry	Wet	Dry	Wet/Dry
Benguet n,85	**28**	**28**	**31**	**29**	**20**	**24**
%	**33**	**33**	**36**	**34**	**24**	**28**
Atok	2	11	0	12	1	0
Kabayan	1	2	13	2	0	14
Kapangan	5	2	5	2	3	7
Kibungan	9	0	0	0	9	0
Mankayan	0	1	7	5	0	3
Tuba	3	1	2	2	1	1
Tublay	8	11	4	6	6	11
Nueva Vizcaya n,46	**16**	**18**	**12**	**12**	**12**	**22**
%	**35**	**39**	**26**	**26**	**26**	**48**
Bambang	11	0	6	2	1	14
Kasibu	1	7	2	9	1	0
Kayapa	0	9	0	0	9	0
Sta. Fe	4	2	4	1	1	8
Total n,131	**53 (40)**	**37 (28)**	**41 (31)**	**41 (31)**	**32 (24)**	**46 (35)**

The occurrence of fusarium wilt disease is slightly associated with the time of planting and harvesting as shown by the contingency coefficient of 0.197 and 0.023, respectively (Table 17). Tuber bulking shows a positive correlation with rainfall and relative humidity (Chowdhury, 1994 as cited by Ravi and Suravanan, 2012), so that the occurrence of SPFW during the wet season will reduce root yield. Time of planting sweetpotato is done both at the onset of the wet months (March-May) and onset of dry months (September to December) in Benguet and Nueva Vizcaya (Gayao, Meldoz and Backian, 2013 and 2014). Harvesting is done 3-5 MAP in Nueva Vizcaya and up to 8 MAP in Benguet.

Table 17. Association of planting/harvesting time to occurrence of sweetpotato fusarium wilt in Benguet and Nueva Vizcaya

PLANTING TIME	FUSARIUM WILT SEVERITY					Total	%
	MILD		MODERATE	SEVERE			
	1	2	3	4	5		
Wet months	2	3	2	8	39	**54**	**41**
Dry months	2	1	2	4	27	**36**	**28**
Wet/dry months	0	1	2	11	27	**41**	**31**
Total, n=131	**4**	**5**	**6**	**23**	**93**	**131**	**100**
%	**3**						
x value=38.57, p.19ns			*Contingency coefficient=0.197*				
HARVEST TIME							
Wet months	4	2	17	10	8	**41**	**31**
Dry months	0	1	6	7	18	**32**	**25**
Wet/dry months	1	2	22	5	16	**46**	**35**
3-4 MAP	0	0	3	2	4	**9**	**7**
Anytime when needed	0	0	3	0	0	**3**	**2**
Total	**5**	**5**	**30**	**9**	**46**	**131**	**100**
%	**7**	**2**	**32**	**10**	**48**		
			*P-value=0.023**				

Multiple response

Source of planting materials. Planting materials used by farmers were vine cuttings. One farmer from Kibungan mentioned the use of seeds. Though sweetpotato can also be reproduced sexually by seed, this is only used for breeding purposes. Keeping of farm-saved planting materials is still the predominant practice. It is very seldom that the indigenous growers who cultivate and plant small areas to sweetpotato crop, source out their planting materials from purchases or from others. Mostly, planting materials are from their own existing crop even with the occurrence of the SPFW disease as shown in Table 18. In Volume 1 of this project report, loss of planting materials was seen as an effect of the disease. In this Volume 2 report, planting material is looked at as a potential cause of the disease where results show a moderate association of the source of planting material and disease severity at a contingency coefficient of 0.458 before and 0.457 after SPFW incidences.

Table 18. Association of source of planting materials to occurrence of sweetpotato fusarium wilt in Benguet and Nueva Vizcaya

SOURCE OF PLANTING MATERIAL	FUSARIUM WILT SEVERITY					BEFORE SPFW, n=132		AFTER SPFW, n=132	
	MILD		MODERATE	SEVERE					
	1	2	3	4	5	#	%	#	%
Before									
Own	7	5	39	6	57	**116**	**88**	**85**	**64**
Purchased	1	0	2	0	0	**3**	**2**	**14**	**11**
From others	2	3	12	5	11	**43**	**33**	**50**	**38**
Total, n=132	**9**	**8**	**53**	**11**	**68**				
%	**7**	**6**	**40**	**8**	**52**				
*x^2= 34.752/ p.004***			*Contingency coefficient*			*.458*		*.457*	

Varieties. Since there is limited source of clean planting materials and that most of the growers interviewed are not aware of tissue cultured planting materials, their observed susceptibility and tolerance of their existing varieties signify important information in the prevention and control of SPFW disease. The more popular market-accepted varieties *Swerte* (red skin, yellow flesh, smooth skin), the very old variety *Kalbo-oy* and *Gislayan/Gihay/Gislay* top the list of the observed tolerant varieties, although few of the sweetpotato growers says so at 33%, 27% and 20%, respectively (Table 17). The less popular varieties *Violet* (purple skin and flesh) *Toclong, Sablan, Decolores, Taiwan, Miracle* and *Haponita*, *Imelda*, *Manila*, *Tokian*, *Mosling* or *Motling*, *Halpido*, *Pakak* and *Apagong* are among the varieties that showed tolerance to fusarium wilt disease, although these were not spared from showing symptoms of the disease. Just like the varieties *Decolores, Motmot, Manila, Kalbo-oy, Pandesal, Gislay, Hapido, Tagala, Hapido, Bukagan, Haponita, Tungga, Miracle and Atok,* where some growers observed as susceptible while others observed as tolerant. The indigenous growers observed tolerance against disease as their defense mechanism to limit spread of the disease and for them to continuously grow sweetpotato. Sweetpotatoes are rich in polyphenols, proteins, vitamins, minerals and some functional microcomponents. Polyphenols have been associated with resistance to many diseases including fusarium wilts. This must also be observed by research and extension workers in the introduction of new high yielding varieties.

Factors such as location, time of planting, source of planting materials used may have affected their reaction to the disease. Since most of the indigenous farmers do not apply fertilizer in their crop, nutritional disorders might have been a limiting factor and have contributed to the reduction in tolerance to pests and diseases.

Table 19. Varieties observed by growers as tolerant or susceptible to sweetpotato fusarium wilt in Benguet and Nueva Vizcaya n,132

SUSCEPTIBLE VARIETIES			TOLERANT VARIETIES		
LOCAL NAME	**#**	**%**	**LOCAL NAME**	**#**	**%**
Decolores	22	17	*Swerte*	44	33
Motmot	17	13	*Kalbo-oy*	36	27
Manila	13	10	*Gihay,Gislay, Gislayan*	26	20
Kalbo-oy	11	8	*Violet*	15	11
Gihay, Gislay, Gislayan	10	8	*Toclong*	9	7
Pandesal	9	7	*Taiwan*	7	5
Tagala	7	5	*Sablan*	6	5
Violet/ Bukagan	7	5	*Atok*	5	4
Atok	6	5	*Colores/Decolores*	5	4
Tungga or Pag-ibig	6	5	*Santa Fe*	5	4
Miracle	4	3	*Hapon/Haponita*	4	3
Motmot	4	3	*Miracle*	4	3
Hapon/Haponita	4	3	*Imelda*	3	2
Karot/Kinmarot	4	3	*Manila*	3	2
Badyongan	4	3	*Tokano*	3	2
Santa Fe	3	2	*Tokian*	3	2
Pakak	3	2	*Apagong*	2	2
Bodiweng	3	2	*Mosling/Motling*	2	2
Galic	3	2	*Pakak*	2	2
Bangkudal	3	2	*Bukagan*	1	1
Dalupirep/Dalupid	3	2	*Haponita*	1	1
Swerte	2	2	*Motmot*	1	1
Apagong	2	2	*Pandesal*	1	1
Tokian	1	2			
Immitlog	1	2			

The varieties *Kalbo-oy, Bukagan, Violet, Tokian, Taiwan, Manila, Miracle, Hapon* or *Haponita, Imelda, Swerte, Tagala* or *Tagalog, Halpido or Sampido, Karot* or *Kinerots, Tokano, Immitlog and Pakak* are also varieties known, grown and utilized by indigenous people in Northern Philippines (Gayao, Meldoz and Backian, 2017) documented as far back in the 1990's.

Fertilizer and pesticide use. Majority of the growers do not use pesticides (87%) in their sweetpotato crop, more (93%) in Nueva Vizcaya than in Benguet (86%) where 33% of the farmers claimed to use organic fertilizer like the ashes and compost available in their farms or otherwise none is applied (68%). Differences in fertilizer use among farmers in the municipalities of Benguet and Nueva Vizcaya are highly significant. The use of pesticide among the municipalities is significant but not between the provinces (Table 20).

Table 20. Fertilizer and pesticide use in sweetpotato among growers in Benguet and Nueva Vizcaya

PROVINCE/ MUNICIPALITY	FERTILIZER USE			PESTICIDE USE		
	None	**NPK /Inorganic**	**Organic**	**None**	**Insecticide**	**Fungicide**
Benguet n,86	**40 (47%)**	**28 (33%)**	**21 (24%)**	**74 (86%)**	**11 (13%)**	**1 (1%)**
Atok	2	3	8	11	2	
Kabayan	17	0	0	17		
Kapangan	5	1	6	12		
Kibungan	9	0	3	9		
Mankayan	3	2	3	7	1	
Tuba	2	2	0	4		
Tublay	2	20	1	14	8	1
Nueva Vizcaya n,46	**43 (93%)**	**3 (7%)**	**0**	**43 (93%)**	**2 (4%)**	**2 (2%)**
Kayapa	9	0	0	9		
Bambang	17	0	0	17		
Kasibu	7	3	0	7	2	1
Santa Fe	10	0	0	10		
Total n,132	**83**	**31**	**21**	**117**	**13**	**3**
%	**63**	**23**	**16**	**89**	**11**	**2**
x^2 value (Province)	*32.472, p.000**			*4.873, p.301[ns]*		
x^2value (Municipality)	*202.122, p.000***			*62.386, p.013**		

Further, the association of fertilizer and pesticide use to occurrence of SPFW is weak and not significant (Table 21) disproving assumption that the use of fertilizer contributes to occurrence of disease. Use of chemical pesticides for the other crops grown, which, when abused led to pesticide resistance and destruction of useful parasites and predators (Lenne, 2000).

Table 21. Association of fertilizer and pesticide use to occurrence of sweetpotato fusarium wilt in Benguet and Nueva Vizcaya

PESTICIDE USE	FUSARIUM WILT SEVERITY			TOTAL	%
	MILD	MODERATE	SEVERE		
None	6	48	63	117	89
Insecticide	1	4	7	12	9
Fungicide	1	0	2	3	2
x^2value = 19.021 p-.763^{ns}		*Contingency coefficient = 0.268*			
FERTILIZER USE					
None	5	36	42	83	63
NPK/Commercial	2	10	19	31	23
Organic	1	6	14	21	16
Total n,132					
%					
x^2 value=16.995 p-.386^{ns}		*Contingency coefficient=0.386*			

Other plants affected. Other plants are also host maybe to other strains of fusarium wilt, but nevertheless display similar symptoms as observed by the sweetpotato growers. Most observed are banana, pod beans and, string beans, tomato ginger, taro, tannia, (23-31%); and less (below 8%) on pechay, peanut, chayote, cucumber, cassava, eggplant and greater yam (Table 22). These are the same crops planted in their swidden farms and vegetable gardens. Incidence and severity as well as possibility of these observed diseases to transfer to the sweetpotato should be established.

Table 22. Other plants affected with fusarium wilt as observed by sweetpotato growers having SPFW symptoms in Benguet and Nueva Vizcaya

OTHER PLANTS AFFECTED	n,132	%
Banana	25	26
Beans/string beans	22	22
Tomato	17	17
Ginger	13	13
Eggplant	3	3
Peanut	3	3
Cucumber	2	2
Pechay	2	2
Potato	2	2
Chayote	2	2
Bell paper	1	1
Papaya	1	1
Ubi or yam	1	1

No answer=34

FusariumWilt Management/ Coping Mechanisms

Similar to other diseased crops, 46% of the growers have no definite practice for disease control. Sweetpotato showing symptoms of fusarium wilt disease are left alone in the field to continue growth or die. If it did continue to produce/enlarge roots, then the growers get the good roots or clean them (11%) for own home use and leave the trimmings/ diseased roots and plants in the farm. Cleaning and utilizing the good ones can be a factor in disease dissemination because of latent infection. Some farmers (17%) uproot the diseased sweetpotato plants and throw them just beyond the borders of the farm or in a compost pile together with other weeds which will not eradicate the disease since the pathogen is soil-borne. Others (9%) abandon the farm and transfer to new farm sites for sweetpotato growing. Seven among the respondents (5%) attempted spraying while burning or burying diseased plants and replacing susceptible varieties is being done by few (7-12%) growers (Table 23).

Table 23. Management and coping mechanisms of growers for sweetpotato fusarium wilt incidence in Benguet and Nueva Vizcaya

MUNICIPALITY	SFW MANAGEMENT/ COPING MECHNISMS						
	NONE	UPROOT/ THROW	CLEAN/ USE/LEFT	ABANDON/ TRANSFER	SPRAY	BURN/ BURY	REPLACE VARIETY
Atok	4	3	1	0	0	0	5
Kapangan	12	0	0	0	0	0	0
Kayapa	0	9	0	0	0	0	0
Kibungan	9	0	0	0	0	0	0
Bambang	17	0	0	0	0	0	0
Kasibu	0	3	2	5	0	0	0
Santa Fe	7	0	3	0	0	0	0
Kabayan	0	1	1	5	1	5	4
Mankayan	1	1	5	1	0	1	0
Tuba	1	2	0	0	0	0	1
Tublay	10	4	3	1	6	1	2
Total, n=132	**61**	**23**	**15**	**12**	**7**	**7**	**12**
%	**46**	**17**	**11**	**9**	**5**	**5**	**9**

*x^2value=292.677, p.000***

Reporting of the disease

This documentation study was prompted since being informed by some farmers and the local government agriculture units. As shown in Table 24, the fusarium wilt problem was first reported by 36% of the farmers to the local government agriculture extension workers personally or through their village or association leaders. Hence, it is often through the initiative of local government units like the municipalities of Kayapa, Kabayan and Atok, that research and extension services will reach the farmers.

Table 24. Reporting of SPFW to agriculture and extension services

PROVINCE/ MUNICIPALITY	NONE	REPORTED
Benguet	**54**	**29**
Atok	3	10
Kapangan	9	3
Kabayan	4	10
Kibungan	9	0
Mankayan	8	0
Tuba	3	1
Tublay	18	5
Nueva Vizcaya	**27**	**19**
Kayapa	0	9
Bambang	17	0
Kasibu	10	0
Santa Fe	0	10
Total n, 132	**81**	**48**
%	**61**	**36**

*x^2 value=83.894, p.000***

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Regardless of area planted to sweetpotato (<500m^2 to 1 ha) in swidden farms (*uma*) or in backyard gardens where sweetpotato is planted as one of the mixed crops; or in paddy fields and vegetable gardens as a monocrop and rotation crop; the sweetpotato crop in Benguet and Nueva Vizcaya were hit by the fusarium wilt disease. The disease was first observed in 2012 by 92-94% of farmers who grew sweetpotato both as cash crop and for home consumption. Rootcrops, rice, vegetables and legumes, and fruits are planted by the sweetpotato growers.

Among the 12 sweetpotato insect pests and diseases, SPFW and weevil were considered most damaging by 100% and 73% of the growers, respectively. SPFW causes yellowing of the lower, older leaves, falling off of leaves and death of stems/vines. Majority of growers (55%) rated severity of the disease as severe based on percentage decrease in root yield that ranged from 76-100%, 39% rated severity as moderate and only 6% rated severity as mild where decrease in root yield is 25% and below. Almost all (82%) of the growers agreed that root sizes became smaller and percentage decrease in root yield ranged from less than 25% to 100% because of SPFW disease.

Of the factors affecting incidence and severity of SPFW, climatic conditions, planting materials and harvesting time showed closer association. Changing climatic conditions had a greater effect on harvesting period than planting time. If planting materials are sourced from previously infected crop, the probability of SPFW was also higher.

Other probable causes include cropping system, planting time, use of fertilizer and pesticides, varieties and other crops grown (contingency coefficient of 0.339 to 0.372). Sweetpotato is just one of the crops planted and among the crops planted in mixed cropping system. Banana, ginger, taro, tannia, tomato and beans showed disease symptoms similar to the sweetpotato fusarium wilt. Few (17%) apply inorganic fertilizer and majority (74%) does not use pesticides. There is very limited choice of varieties observed tolerant and sometimes conflicting among the growers though the indigenous growers observed susceptibility and tolerance of their existing varieties as their defense mechanism to limit spread of the disease and for them to continuously grow sweetpotato.

Researches towards identification of resistant varieties can be considered as sweetpotato fusarium wilt can satisfactorily be controlled with resistance. Likewise, regular field monitoring particularly on diseases and other economically important pests should be strengthened and this can be done in participation with the Department of Agriculture and the academe. Use and production of clean planting materials (CPM) for continuous supply can become a standard among farmers as these have an impact towards sustainable sweetpotato production. This can be achieved by strengthening the extension programs with the participation of the Local Government units (LGUs).

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TARO LEAF BLIGHT (*Phythophthora colocasiae*), TARO BEETLE (*Papuana spp.*) AND OTHER TARO INSECT PESTS AND DISEASES AFFECTING FARMS OF INDIGENOUS GROWERS IN BENGUET AND NUEVA VIZCAYA, PHILIPPINES

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ABSTRACT

This research documented incidence and severity of taro leaf blight and taro beetle within the context of farm households' environment in 12 barangays of Benguet and Nueva Vizcaya, Philippines. Samples of affected crops showing symptoms of the disease were also collected from the study sites to verify the causal pathogen of leaf blight.

One hundred percent of the taro growers observed taro leaf blight incidence and 86% observed taro beetle damaging their crop. More growers rated taro leaf blight incidence as moderate to severe, and taro beetle damage as mild to moderate. Despite the high pest prevalence, most farmers do not employ any means to manage the pests except for those engaged in taro cash crop in which case the application of chemical pesticides is undertaken.

Other diseases and insect pests affecting taro were identified during the study such as rot, rust or *date*, cutworm or *rimas/dimas*, hornworn or *ataro*, white fly and aphid (*aplat*), white grub (*hapiloy/balikutkot/loklok*), hopper, snail (*kuhol*), beetle (*tolbing*) and others locally known as *kawaweng/kawatang*, *safidol* and *batungol/arabas/dangaw/shangew*.

INTRODUCTION

Several pests threaten taro production in different parts of the world but the taro leaf blight (TLB) and taro beetle (TB) are the common complaint of taro farmers in the Province of Benguet and adjacent areas. Literatures on TLB and TB are available online, but there is limited information on the extent of infection within local government coverage areas for agriculture extension and research services to act on these problems. Hence, this research documented incidence and severity of these pests within the context of taro farm households' environment in Benguet and Nueva Vizcaya, Philippines.

Taro Production. Taro ranks 9th among food crops (Gananca et al., 2015) and fifth among the most harvested root crop in the world (Adamako et al., 2016) with total production of 12 million tons on 2 million hectares (FAOSTAT, 2010). It is largely produced in developing countries by smallholder farmers under low input production system (Sing et al., 2012; Taylor & Iosefa, 2013). Taro plays a significant part in the culture and economy of many rural areas (Brown & Daigneault, 2014) of Asia, Africa and the Pacific Islands where it is an important staple food (Deo et al., 2009; Gananca et al., 2015; Gebre et al., 2015) as well as a source of revenue to farmers (Azeez & Madukwe, 2010; Chiejina & Ugwuja, 2013; Onyeka, 2014). However, the escalating problem on pests and diseases is damaging the productivity of taro which bears negative impact on trade and food security (Deo et al., 2009). In Asia and the Pacific regions, the taro industry is currently threatened by taro beetle and taro leaf blight (FAO, 2017) which are considered the most serious threats to the crop (Brooks, 2008; Deo et al., 2009; Singh et al., 2012; Tyson, 2012; Onyeka, 2014; Adinde et al., 2016).

Taro Leaf Blight (TLB). Several diseases threaten taro production in different parts of the world (Onyeka, 2014; Plantvillage, 2016). Among the diseases affecting the crop, taro leaf blight (TLB) has been the most devastating (Brooks, 2008; Singh et al., 2012; Tyson 2012; Onyeka, 2014; Adinde, 2016). It has been reported in many countries (Brooks, 2008) to have caused significant drop in production (Brooks, 2008; Adinde, 2016). In Nigeria, for instance, production has drastically declined by 60% (Chiejina & Ugwuja, 2013) and in Samoa where the taro industry was devastated by the outbreak of the disease (Iosefa et al., 2017; Rao et al., 2010) suffering an annual loss in foregone domestic taro consumption valued at WST11 million and a taro export market valued at WST9 million (McGregor 2011). Taro leaf blight is caused by the fungi, *Phytophthora colocasiae* (Erwin & Ribeiro, 1996; Brooks, 2008; Singh et al.; 2012, Tyson, 2012; Onyeka, 2014). The growth of the pathogen is encouraged by hot, humid and wet environment while rain splashes aid in the spread of fungal spores (Brooks, 2005; Cabi, 2016; Omeje et al., 2016; Carren et al., 2018). The symptoms on the leaf are the most noticeable disease damage (Taylor & Iosefa, 2013) but corm rot may also be observed soon after harvest (Singh et al., 2012) as well as petiole rot in susceptible varieties (Taylor & Iosefa, 2013; ACIAR, 2008). At the outset of the disease, small water-soaked lesions form on the leaves which broaden and become purplishbrown with yellowish margins (Brooks, 2005; Singh et al., 2012; Adinde, 2016). Concentric regions commonly develop on the lesions and secrete yellow to brown liquid droplets forming dark brown hard deposits (Cabi, 2016; Singh et al., 2012; Adinde, 2016). Atop the diseased tissues, fungal spores may grow and take on a white powdery appearance (Cabi, 2016). The lesions continue to enlarge and frequently coalesce as the disease advances. Hollows of no particular shape or size are created as the infected part of the leaf disintegrates. Usually, a healthy taro has 6-7 leaves that live up to 40 days. On the contrary, defoliation occurs at about 20 days after TLB-infection resulting to a fewer leaves (3-4) (Cabi, 2016). Consequently, there is a decline in the photosynthetic activity of the crop as the number of functioning leaves and/or leaf area is reduced (Jackson, 1999; ACIAR, 2008).

Taro beetle. Taro beetles, *Papuana* and *Eucopidocaulus* species (Coleoptera: Scarabaeidae), are important pests of taro in the South Pacific (Thistleton 1984; Macfarlane 1987; Waterhouse and Norris 1987; ACIAR, 2008). Most species of taro beetle belong to the genus *Papuana*. Of the 19 known species (Endrodi 1971, 1985), eight are recorded as major pests of taro. In addition, another species, *Eucopidocaulus tridentipes* (previously *Papuana tridentipes*) has recently also been shown to be a major pest of taro. The beetles are native to the Indo-Pacific Region with 14 of the 19 species occurring on the island of New Guinea (Endrodi 1971, 1985). The beetles are the main constraint to improving the yield and quality of taro production in PNG, Solomon Islands and Vanuatu. Repeated taro growing in the same field is not possible in these countries and as a result, forest areas are cleared for new plantings. Taro fields therefore tend to be in isolated bush areas, a long way from dwellings, which causes considerable hardship to taro farmers. Over the years, this has led to less interest in taro growing and a shift in dietary habits. In Fiji, taro beetle resulted in production of export taro being shifted to the island of Taveuni. The taro beetle is therefore of great concern to affected countries.

Taro is highly susceptible to invasion from taro beetles, which burrow into the corms and weaken the plants, rendering them unmarketable and prone to rot (Brown & Daigneault, 2014). The beetle inflicts severe damage not only on taro but on other important root crops and plants as well across Africa and Asia (Faithpraise et al., 2014). Adult taro beetles burrow into the corms of taro and other aroids, making smooth-sided tunnels of the same width as the beetles. In severely damaged plants, the tunnels run together to form large cavities and secondary rots often develop. When populations are high, the beetles move into the taro gardens at an early stage and subsequent feeding at the base of plants leads to wilting and plant death. Plant death can also occur in newly planted taro, while plant vigor and growth is retarded in established plants. The beetles rarely feed on corms exposed above the soil (ACIAR, 2008). *Papuana* beetles have a wide host range and, therefore, capable of surviving under harsh environments. The beetles can survive without food for several weeks (FAO, 2003).

A mated, fertile, adult taro beetle female can lay up to 300 hundred eggs during its life time which are viable for 3 months (FAO, 2003). Before emergence, there is a 1-week pre-oviposition period during which the female feeds aggressively to obtain energy and then disperses to breeding sites for oviposition. Eggs are laid singly with an average of one per day. The adult beetles can live up to 22 months in captivity but probably less under natural conditions. Males tend to remain in the taro gardens, while females disperse to breeding sites. The life cycle is egg, first instar and second instar larvae (approx. 18 days each), and third instars (55 days). The prepupal and pupal stages are 7 and 30 days, respectively, giving a total life cycle of 146 days. The length of the life cycle is influenced by the availability of nutrients, soil moisture and temperature.

The beetle prefers wet/moist soil, especially loams or silty loams with plenty of organic matter. Oviposition takes place in any suitable habitat that is moist and protected from natural enemies, such as under logs, along river banks and in the fibrous roots of grasses. Adult beetles are common once the primary forest is disturbed and *Alocasia* and *Musa* spp. are re-established. Damage to taro in areas where logging has occurred is common. Soon after emergence, the young adult beetles fly into taro gardens to feed. They remain in the soil and prefer to feed on corms of *Colocasia esculenta*. The females, however, leave the gardens to look for suitable sites for oviposition. These sites include felled logs, grassland with silty loam topsoil, river and stream banks with good alluvial soil deposits. They also like disturbed environments (logging areas, gardens under fallow, road sides) where there are plenty of alternate host plants such as *Alocasia* spp, *Marattia* spp, *Musa* spp. and *Saccharum* spp. Therefore, immature stages are not commonly found in taro gardens. In the primary forest, the beetles survive on *Angiopteris* spp. (FAO, 2003).

METHODOLOGY

Selection of Sites and Respondents

The incidence and severity of TLB and TB were surveyed across nine barangays and six municipalities of Benguet and in three barangays in one municipality of Nueva Vizcaya as shown in Table 1. The selection of *barangays* (villages) as study sites was based on secondary information gathered from provincial and municipal records and interviews in major taro producing areas where incidence of taro leaf blight and taro beetle have been reported. A total of 71 taro household growers were interviewed and majority (63) was represented by the female household member.

Table 1. Study sites and number of respondents in Benguet and Nueva Vizcaya

PROVINCE/MUNICIPALITY	BARANGAY	NO. OF RESPONDENTS		
		MALE	FEMALE	TOTAL
BENGUET				
Atok	Naguey		4	4
Kabayan	Tawangan		12	12
Mankayan	Cabiten	2	6	8
Sablan	Bayabas	4	3	7
Tuba	San Pascual Taloy Sur	1	11	12
Tublay	Basil		16	16
NUEVA VIZCAYA				
Kayapa	Besong	1	6	7
	Amelong-labeng		4	4
	Kayapa Proper East		1	1
TOTAL		**8**	**63**	**71**

Data Gathering Procedure and Field Sampling

Group interview (GI) and focused group discussion (FGD) were conducted in selected villages using an open-ended questionnaire as guide.

During the group interview, the taro growers were asked to identify insect pests and diseases observed in their fields that affect production. A picture of various disease symptoms and pests was shown for easy identification of participants focusing on taro leaf blight and taro beetle. This was followed by a focused group discussion where participants shared their view as to the climatic conditions leading to the appearance of symptoms and insect damage, plant parts and varieties that were infected/infested, severity of the pest and disease, and coping mechanisms employed. Further, the participants were requested to provide information of their farm profile including taro farming practices.

After the GI and FGD, a field visit to selected taro growing areas of the respondents followed for an ocular assessment of the incidence and severity of taro leaf blight and taro beetle damage. Foliage and stalks showing symptoms of blight were collected, placed in individual plastic bags and brought to the laboratory for pathogen identification.

Assessment of Taro Blight and Beetle Incidence and Severity

The assessment of taro leaf blight and taro beetle damage included the viewpoint of the farmer-respondents and on-site surveys undertaken by the researchers.

The percentage of farmers who observed leaf blight and beetle in their farms was referred to as **Perceived Incidence** and was assessed using the following formula:

$$\textbf{Perceived TLB and TB Incidence} = \frac{\text{Number of farmers who observed taro blight and beetle}}{\text{Total number of taro growers interviewed}} \times 100$$

The farmers further estimated **Observed Severity** using a three-point scale as follows:

Scale	Description
1	Mild (at least 75% of crop was harvested)
3	Moderate (40-60% of crop was harvested)
5	Severe (at least 25% of crop was harvested)

On the other hand, the researchers visited selected taro growing areas of the respondents for an ocular assessment of disease infection and pest infestation. Incidence was determined as the ratio of the number of taro plants with the disease symptoms or insect pest damage to the total number of taro plants multiplied by 100 (Campbell and Neher, 1994). In some locality where the taro growing area is wide such as in Naguey, Atok, the taro field was subdivided into blocks and assessment was made on selected block/s.

Similarly, disease severity, which is defined as the percentage of the area of taro leaves infected over the total leaf area (Campbell and Neher, 1994), was assessed in the various fields visited. Depending on the field size, a minimum of twenty (20) plants were randomly rated for severity following the formula below.

$$\textbf{TLB and TB Incidence (\%)} = \frac{\text{Number of infected taro plants}}{\text{Total number of taro plants}} \times 100$$

$$\textbf{Disease Severity (\%)} = \frac{\text{Area of taro leaves infected}}{\text{Total area of taro leaves}} \times 100$$

Data Analysis

Most of the data were analyzed using excel spreadsheet and descriptive statistics. When applicable, data analysis using cross-tabulation, Pearson chi-square and contingency coefficient correlation using the SPSS software was employed. Level of significance was set at five percent.

Laboratory Analysis

Leaf blight-infected leaves collected from selected farmer's field in each study site were stored in separate plastic bags and brought to the NPRCRTC Plant Health Clinic for isolation and identification. A 1x1cm leaf disc with lesions showing sporulated growths was mounted on a slide and observed microscopically at 100x magnification. For pathogenicity test, healthy-looking taro leaf discs measuring 5x5cm were placed on sterile Whatman filter paper soaked with distilled water and placed in petri dishes. The leaves were inoculated with 2 ml of the sporangial suspension containing sporangia of *P. colocasiae*.

RESULTS AND DISCUSSION

Characteristics of Taro Farmer-Respondents

Sources of cash income. The taro farmers rely on multiple sources to earn a living. Majority (99%) depend on the sale of their produce for cash income specifically in the municipalities of Sablan, Atok, Tuba, Kabayan, Mankayan and Tubaly in Benguet and in Kayapa, Nueva Vizcaya (Table 2). While farming is their main livelihood, 51% of the other taro growing households receive salaries either as employees or informal wage workers; and others are able to receive grants (27%) such as the *Pantawid Pamilyang Pilipino Program (4Ps)* of the national government which provide conditional cash transfer to poor households. Only few are involved in business (14%) as this requires capital.

Table 2. Sources of cash income of taro growers in Benguet and Nueva Vizcaya

BARANGAYS (n=71)	SALARY/ WAGES	CROP SALES	BUSINESS	OTHERS
Bayabas	4	6	2	
Naguey	3	4	1	2
Cabiten	4	8	2	6
Tawangan	8	12		3
Taloy Sur	1	6	1	2
San Pascual	2	6	2	1
Basil	14	16	2	5
Besong		7		
Amelong-labeng		4		
Kayapa Poblacion East		1		
Total	**36**	**70**	**10**	**19**
%	**51**	**99**	**14**	**27**

multiple response x^2value=1.904E2, p.000*

Characteristics of Taro Farms

Taro farming in Benguet and Nueva Vizcaya is no different from those in Asia, the Pacific, Africa and the Caribbean. Global taro production comes from developing countries characterized by smallholder production systems relying on minimum external resource inputs. This makes the crop very important for food security especially among subsistence farmers (Singh, et al., 2012).

Farmscape planted to taro and other crops. Taro is grown in 4 kinds of farms. The *uma* is located in sloping hills or mountain sides (Gayao, Meldoz and Backian, 2013-2014) while backyard gardens are small plots planted to crops for kitchen use. These are usually operated using mixed cropping system and low input to adjust to available labor and resources. On the other hand, the *talon* is characterized by a flat and/or terraced farm oftentimes planted to rice during rainy season and sometimes called gardens (18%) when planted to vegetable cash crops, sweetpotato and taro and utilized mainly for cash crops. Table 3 shows that majority of the respondents cultivate taro in *uma* or swidden farms (80%), followed by backyard gardens (68%), *talon* or rice field (54%) and lastly in gardens (18%).

Two production systems have been observed in the study. Most of the sites practice rainfed/dry cultivation characterized by subsistence production while irrigated/wet production is observed in areas where taro is a cash crop or cultivated for commercial purpose such as in Naguey, Atok, Benguet.

Table 3. Types of farm operated by taro household growers in Benguet and Nueva Vizcaya

BARANGAY	*UMA/* SWIDDEN	*TALON/* RICE FIELD	GARDEN	BACKYARD GARDEN
Bayabas	6	5	3	1
Naguey		4		2
Cabiten	6	7		5
Tawangan	6	2	2	9
Taloy Sur	6	1	2	6
San Pascual	6	4		5
Basil	15	13	1	12
Besong	7		3	5
Amelong-Labeng	4	1	4	2
Kayapa Poblacion East	1	1		1
Total, n= 71	**57**	**38**	**13**	**48**
%	**80**	**54**	**18**	**68**

multiple response* *x^2value= 2.707E2, p.000*

Farm size planted to taro and other crops. The total area operated by taro growers is shown in Table 4. However, the actual area planted to taro is smaller which ranged from 10 to 373 m^2 (Gayao, et al., 2019) since mixed cropping taro is just one among many crops planted for multiple household uses.

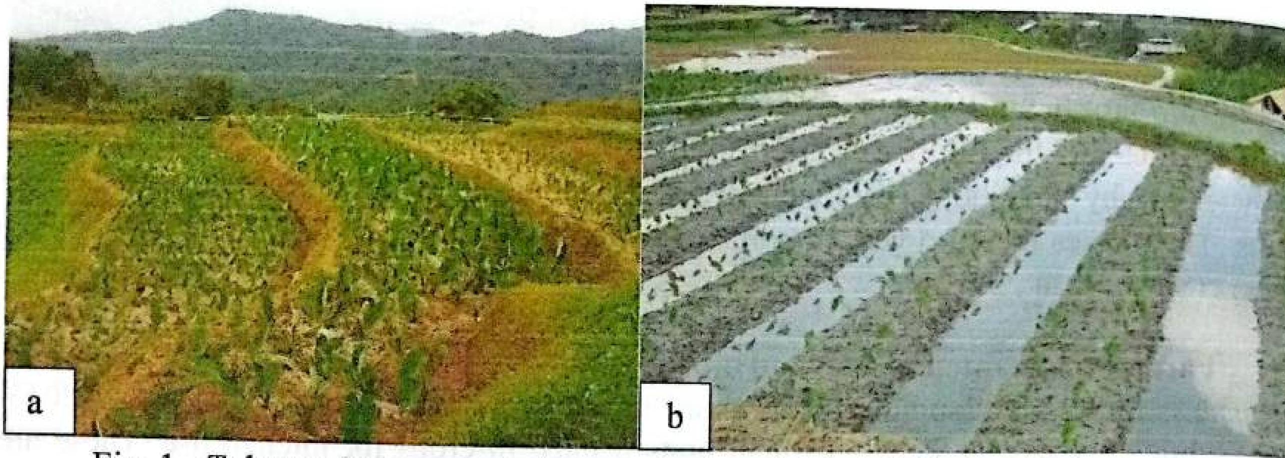

Fig. 1. *Talon* as farm scape in taro production. (a) Rainfed taro area in Bayabas, Sablan, Benguet; (b) Irrigated taro farm in Naguey, Atok, Benguet

Table 4. Total farm sizes operated by taro growers in Benguet and Nueva Vizcaya

BARANGAY	500SQM and BELOW	>500 TO 1000SQM	>1000 TO 0.5HA	>0.5HA TO 1 HA	>1 HA
Bayabas				1	6
Naguey	1	1	2		
Cabiten	1	1	1	3	2
Tawangan	2	1	6	1	2
Taloy Sur		2	2	2	
San Pascual	1		2		3
Basil	4	4	5	2	1
Besong	6				1
Amelong-Labeng	2				2
Kayapa Poblacion East					1
Total- all sites, n=71	**17**	**9**	**18**	**9**	**18**
%	**24**	**13**	**25**	**13**	**25**

*x^2value= 1.430E2 p.000***

Purpose of crops planted. The reasons for taro production differ among the respondents (Table 5). Majority of the growers (97%) mainly grow taro for household and leftovers are given as animal feed (32%). If there is demand or extra produce, taro is marketed (83%) to augment income. During community festivities or special occasions, taro is given as gifts (10%). Taro is an important food resource especially among indigenous farmers hence, 73% keep choice tubers as planting materials for the next cropping season.

Table 5. Household purpose of taro and other crops planted by taro growers in Benguet and Nueva Vizcaya

BARANGAY	SALE	FOOD	FEED	GIFTS	PLANTING MATERIALS
Bayabas	6	6	2		7
Naguey	4	4	1		4
Cabiten	7	8	4		6
Tawangan	11	11	1		9
Taloy Sur	6	6	5		6
San Pascual	3	6	2	1	5
Basil	13	16	3		15
Besong	5	7	3	3	
Amelong-Labeng	3	4	1	2	
Kayapa Poblacion E.	1	1	1	1	
Total- all sites, n=71	**59**	**69**	**23**	**7**	**52**
%	**83**	**97**	**32**	**10**	**73**

multiple response* *x^2value= 1.798E2, p.000*

Cropping system/pattern. Since taro is planted in swidden farms and backyard gardens, 68% of the farmers consider taro as a mixed crop either as intercrop (42%) or border crop (30%). In barangays Naguey, Cabiten and Tawangan, taro is cultivated as monocrop (49%) in rice fields and gardens and as a rotation crop (41%). In Naguey, where water supply is not a problem, taro is grown as a cash crop (Table 6) in rice fields and gardens.

Table 6. Cropping system and cropping pattern for taro as practiced by growers in Benguet and Nueva Vizcaya

BARANGAY	MONO-CROPPING	MIXED CROPING	MAIN / ROTATION CROP	INTER CROP	BORDER CROP
Bayabas	6	7	7	7	
Naguey	4		4		
Cabiten	7	4	6		2
Tawangan	8	4	2		10
Taloy Sur		6	3	3	
San Pascual	2	6	1	5	
Basil	5	11	5	7	6
Besong	2	5	1	4	2
Amelong-Labeng		4		3	1
Kayapa Poblacion East	1	1		1	
Total, n=71	**35**	**48**	**29**	**30**	**21**
%	**49**	**68**	**41**	**42**	**30**

multiple response* *x^2value* *1.803E2, p.000*
*2.015E2, p.000***

Taro Insect Pests and Diseases

The respondents identified thirteen (13) pests affecting taro, three of which are diseases and 10 are insect pests. One hundred percent (100%) of grower-respondents indicated that the most prevalent were taro leaf blight (TLB) and taro beetle (TB) followed by white grub (*Hapiloy/Balikutkot/Loklok*) among 21% of respondents, and hornworm (*ataro*) among 18% of respondents as shown in Table 7. Other pests observed but at lower frequency were cutworm (*dimas/rimas*), *kawaweng/kawatang*, white fly, *Batungol/Arabas/Dangaw/Shangew*, rot, *safido*, aphid (*aplat*), hopper and rust *(date)*.

Of the insect pests and diseases shown in Table 7, taro beetle, taro leaf blight and damages caused by *safidol*, rot, *aplat*, *kuhol* and snail were identified by the farmers as severe. The corm rot may also be caused by the leaf blight, *P. colocasiae* (Singh, 2012). The corm rot may also be caused by the leaf blight, *P. colocasiae* (Singh, 2012).

Table 7. Insect pests and diseases affecting taro crops in Benguet and Nueva Vizcaya

LOCAL NAME	ENGLISH NAME	RESPONDENTS	
		#	%
	Taro Leaf Blight	71	100%
Tolbing	Taro Beetle	71	89%
Hapiloy/ Balikutkot/ Loklok	White Grub	15	21%
Ataro	Hornworm	13	18%
Rimas/Dimas	Cutworm	6	8%
Kawaweng/ Kawatang		5	7%
	White Fly	4	6%
Batungol/ Arabas/ Dangaw/Shangew		3	4%
	Rot	2	3%
Safidol		2	3%
Aplat	Mealy bugs	2	3%
	Hopper	1	1%
Date	Rust	1	1%

Taro Leaf Blight

Among the diseases affecting taro worldwide including in the provinces of Benguet and Nueva Vizcaya, taro leaf blight (TLB) is of prime importance because it can reduce corm yield, corm quality and leaf yield especially in susceptible varieties (Brooks, 2008; Singh et al., 2012; Tyson 2012; Onyeka, 2014; Adinde, 2016). In Nigeria, for instance, production has drastically declined by 60% (Chiejina & Ugwuja, 2013). In Samoa, the annual loss in foregone domestic taro consumption and export market was valued in millions (McGregor 2011).

Description. The most noticeable disease symptom of taro leaf blight (TLB) observed by the taro growers in Benguet and Nueva Vizcaya are on the leaf. As described also in literatures, small lesions form on the leaves which broaden and become purplish-brown with yellowish margins. The lesions continue to enlarge until hollows are created until the infected part of the leaves disintegrates. The corm may also rot soon after harvest (Taylor & Iosefa, 2013; ACIAR, 2008, Brooks, 2005; Singh et al., 2012; Adinde, 2016). The disease is caused by the fungus –like *Oomycete Phytophthora colocasiae Raciborski* (Singh, et al., 2012).

Plant parts infected. The taro growers observed that TLB damages the leaf, the stalk, the base of the plant and the whole plant including the corms (Table 8) confirming to the aforementioned description.

Table 8. Plant parts of taro damaged by taro leaf blight according to taro growers in Benguet and Nueva Vizcaya

BARANGAY	STALK	LEAF	STALK/LEAF/BASE	WHOLE PLANT
	# of respondents			
Bayabas	1			
Naguey		2		
Cabiten		1	3	2
Tawangan		1	8	
Taloy Sur			5	1
San Pascual		2	3	1
Basil		10	2	2
Total, n=44	*1*	*16*	*21*	*6*
%	*2*	*36*	*48*	*14*

*x^2value=70.323, p.000***

Laboratory analysis. Confirmatory test of the pathogen extracts from the collected infected plants that was cultured in potato dextrose agar medium proved that the infection was caused by *P. colocasiae*.

Incidence. All the taro growers observed 100% occurrence (TLB incidence) of TLB. However, growers highly differ (p.000) in percentage incidence where 38% claimed 40 – 69% incidence especially in Bayabas, Sablan and Tawangan, Kabayan; 34% claimed 5 – 39%, and 28% claimed 70 – 100% incidence in Cabiten, Mankayan (Table 9). The differences could be attributed to rainfall and also to the local environment.

Moreover, 26% of the respondents observed higher TLB incidence during the rainy season than the dry season (11%) (Table 10). TLB damage was also noted to be most visible at 3-5 months after planting (24%) until harvest (32%). Considering that corm bulking occurs at 3-5 MAP, disease infection at this stage would compromise corm yield. Another contributing factor to the decrease in harvest is the rapid destruction of leaves. The normal longevity of a healthy leaf is about 40 days but leaves of infected susceptible varieties collapse within 20 days or less (Misra et al., 2008). A healthy taro usually has 6-7 leaves but is reduced to 3-4 leaves when severely infected (Singh, et al., 2012; Cabi, 2016). Fewer number of functional leaves results in reduced net photosynthesis and consequent decrease in corm yield (Brooks, 2005) of up to 50% (Jackson, 1999).

Severity. Most respondents rated the severity of TLB as moderate (42%) and severe (31%) (Table 9). This assessment was based on their previous yield which was affected by the disease. Moderate TLB severity suggest 40-60% harvest, 25 - 60% yield if infection is severe and at least 75% harvest if mild.

Table 9. Incidence and severity of taro leaf blight in selected barangays in Benguet and Nueva Vizcaya

BARANGAY	TLB INCIDENCE	% INCIDENCE			SEVERITY RATING		
		5-39	40-69	70-100	Mild	Moderate	Severe
Bayabas	7		7			7	
Naguey	4	2	2		2	2	
Cabiten	8			8		1	7
Tawangan	12	5	7		4	3	5
Taloy Sur	6	3		3	1	5	
San Pascual	6	1	2	3		1	5
Basil	16	7	4	5	5	6	5
Besong	7	4	3		5	2	
Amelong-Labeng	4	1	2	1	1	3	
Kayapa Poblacion East	1	1			1		
Total, n=71	**71**	**24**	**27**	**20**	**19**	**30**	**22**
%	**100**	**34**	**38**	**28**	**27**	**42**	**31**
x2 value	*74, p.000***	*2.231E2, p.000***			*1.636E2, p.000***		

Fig. Symptoms of taro blight infection in leaves and petiole

Table 10. Stage when TLB damage is most visible according to taro growers in selected areas in Benguet

BARANGAY	1-3 MAP	3-5 MAP	AT HARVEST	AT BULKING	DRY SEASON	WET SEASON	ANY MONTH
	# of respondents						
Bayabas		6					
Naguey		2			2		
Cabiten		2	3			1	
Tawangan				1	4	5	
Taloy Sur						5	1
San Pascual	1	3	1			1	
Basil			13	1		2	
Total, n=54	**1**	**13**	**17**	**2**	**6**	**14**	**1**
%	**1.5**	**24**	**32**	**4**	**11**	**26**	**1.5**

*x^2value=1.64E2, p.000***

Taro Beetle

Taro beetles, *Papuana* and *Eucopidocaulus* species (Coleoptera: Scarabaeidae), are important pests of taro in the South Pacific (Thistleton 1984; Macfarlane 1987; Waterhouse and Norris 1987; ACIAR, 2008). Most species of taro beetle belong to the genus *Papuana*. Of the 19 known species (Endrodi 1971, 1985), 8 are recorded as major pests of taro. In addition, *Eucopidocaulus tridentipes* (previously *Papuana tridentipes*), another species, has recently been shown to be threaten taro production. The beetles are native to the Indo-Pacific Region with 14 of the 19 species occurring on the island of New Guinea (Endrodi 1971, 1985). Onwueme (1999) reported that one species of *Papuana* is present in the Philippines but does not pose a problem. Aloalii et al., (1993), on the other hand, reported the presence of two taro beetle species in the country.

Description. Taro beetles burrow into the stalks and corms and weaken the plants, rendering them unmarketable and prone to rot. When adult taro beetles burrow, smooth-sided tunnels area are created to form large cavities where secondary rots often develop. When the TB moves at the base of plants, their feeding leads to wilting and plant death; or else plant vigour and growth is retarded in established plants (Brown & Daigneault, 2014; Faithpraise et al., 2014). The beetles rarely feed on corms exposed above the soil (ACIAR, 2008).

Males tend to remain in the taro gardens, while females disperse to breeding sites. A mated, fertile, adult taro beetle female can lay an average of one egg per day and can lay up to 300 hundred eggs during its life time which are viable for 3 months. The life cycles of egg is first instar and second instar larvae (approx. 18 days each) and third instar (55 days). The prepupal and pupal stages are 7 and 30 days, respectively, giving a total life cycle of 146 days. Soon after emergence, the young adult beetles fly into taro gardens to feed. The adult beetles can live up to 22 months in captivity but probably less under natural conditions *Papuana* beetles have a wide host range and capable of surviving under harsh environments. The beetles can survive without food for several weeks (www.ediblearoids.org., 2019).

Plant parts affected. The adult beetle lays eggs at the petiole. When eggs develop into the larval stage, they tunnel the stalk which may cause wilting. Tunneling reaches the corm and can even become an entry point of microorganisms that may lead to rotting.

Fig. 3. (a) Taro beetle (*tolbing*) (b) damaged petiole where the adult beetle lay eggs (c) tunneled stalk

Table 11. Plant parts of taro damaged by taro beetle according to growers in Benguet

BARANGAY	STALK	LEAF	CORM	STALK/LEAF/ BASE	WHOLE PLANT	CORM SKIN
	# of respondents					
Bayabas		1				1
Naguey		1				1
Cabiten	1				3	
Tawangan		2	2	1	5	
Taloy Sur		1			5	
San Pascual			1		4	
Basil			9			
Total, n=38	**1**	**5**	**12**	**1**	**17**	**2**
%	**2.5**	**13**	**32**	**2.5**	**45**	**5**

*x^2value=63.126, p.019***

Incidence and severity. Eighty-nine percent (89%) of the taro growers observed the presence of taro beetle (TB). Assessment of incidence highly differs (p.000) among growers in the study areas. The beetle prefers wet/moist soil, especially loams or silty loams with plenty of organic matter (www.ediblearoids.org, 2019). Majority (48%) of taro growers claimed 40–69% incidence especially in Bayabas, Sablan and Tawangan, Kabayan. On the other hand, 37% of the growers who claimed 5–39% percentage incidence similarly assessed TB damage as mild (38%). Thirty four percent (34%) assessed TB damage as severe especially the farmers in Cabiten, Mankayan (Table 12).

At 3-4 MAP, healthy taro plants should already have 6-7 stalks which is the stage when taro beetles are attracted to feast on the plants especially when the crop is planted during the wet season as shown in Table 13. The young adult beetles fly into taro gardens to feed at 4-5 months after the eggs of the insect have hatched.

Table 12. Incidence and severity of taro beetle in Benguet and Nueva Vizcaya

BARANGAY	TB INCIDENCE	% INCIDENCE			SEVERITY RATING		
		5-39	40-69	70-100	Mild	Moderate	Severe
Bayabas	7	2	5		1	6	
Naguey	4	4			3	1	
Cabiten	8		7	1			8
Tawangan	10	5	6	1	5		7
Taloy Sur	6		1	5		1	5
San Pascual	6	3	3		3	3	
Basil	10	9	5	2	7	7	2
Besong	7		6	1	4	1	2
Amelong-Labeng	4	3		1	3	1	
Kayapa Poblacion East	1		1		1		
Total- all sites, n=71	**63**	**26**	**34**	**11**	**27**	**20**	**24**
%	**89**	**37**	**48**	**16**	**38**	**28**	**34**
x2 value	*97.481,p.000***	*2.107E2, p.000***			*1.711E2, p.000***		

Table 13. Stage when TB damage is most visible as observed by taro growers in Benguet

BARANGAY	1-3 MAP	3-5 MAP	DRY SEASON	WET SEASON	ANY MONTH
	# of respondents				
Bayabas				6	
Naguey	2		2		
Cabiten		4			
Tawangan			1	2	5
Taloy Sur			1	1	2
San Pascual				2	
Basil		7		1	
Total, n=36	**2**	**11**	**4**	**12**	**7**
%	**7**	**30**	**11**	**33**	**19**

*x^2value=1.052E2, p.000***

Other Plants with Symptoms of TLB and TB Damage

Taro is usually planted as mixed crop and farmers have observed TLB symptoms and TB damage on crops other than taro (Table 14). First on the list is the root crop tannia locally known as '*galiang*' *(Xanthosoma* spp.*)* which are usually cultivated and sometimes as volunteer plants in borders of swidden farms and gardens. There are inconsistent references, however, pertaining to tannia as a plant host of *Phytophthora colocasiae,* causal organism of taro leaf blight. Taylor and Iosefa (2013) cited that *Xanthosoma* spp. is immune to the disease while CABI (2019) and http://hpc.ilri.cgiar.org (2016) included it among the host plants of the pathogen. NRI (1987), on the other hand, noted that the crop is relatively free from damages by pests or diseases as it is mainly grown on a small scale and not extensively cultivated. This could explain why locals earlier considered tannia as a sturdy plant that is tolerant to almost all kinds of pests. In addition, the dumping of diseased plants and weeds in borders of farms, as commonly practiced by farmers, could have provided a favorable environmental condition for infection and disease development.

The other crops identified by farmers that exhibited TLB symptoms and TB damages are tomato, beans, cabbage and potato which are commonly sprayed with pesticides because of blight, wilt and insects. Table 11 also shows that farmers in Barangay Tawangan in Kabayan, Benguet observed that almost all their crops are infested with pests and diseases and their only known recourse is to spray pesticides based on chemical company's advertisement.

Nevertheless, taro leaf blight pathogen has been reported to have a limited host range and mainly affect species of *Colocasia* spp. and, to a lesser extent, *Alocasia macrorrhiza* (Taylor & Iosefa, 2003; Nelson et al., 2011), *Bougainvillea spectabilis* (great bougainvillea), *Catharanthus roseus* (Madagascar periwinkle), *Xanthosoma* (cocoyam) (CABI, 2019), other cultivars of *Alocasia* spp., *Amorphophallus campanulatus* (elephant-foot yam), *Hevea* brasiliensis (rubber), *Piper betle* (betel), *Vinca rosea* (periwinkle), *Xanthosoma mafaffa* (giant golden taro), *Xanthsoma sagittifolium* (yautia, malanga, tannia, ocumo), and *Xanthosoma violaceum* (blue taro, blue ape) (http://hpc.ilri.cgiar.org, 2016).

Table 14. Other crops affected by leaf blight and beetle pest-symptoms

BARANGAY	CROP	# OF RESPONDENT
Basil, San Pascual, Tawangan, Naguey	Tannia/*galiang*	14
Cabiten, Tawangan	Tomato	9
Basil, Cabiten, Bayabas	Snap/stringbeans/*otong*	8
Tawangan, Basil	Cabbage	6
Tawangan	Potato	5
Tawangan, Cabiten	Pechay	4
Tawangan, Cabiten	Eggplant	3
Tawangan	*Sili*	3
Bayabas, Naguey	Banana	3
Tawangan	Corn	2
Tawangan	Garden pea	2
Bayabas, Taloy Sur	Cucumber	2
Cabiten	Cassava	2
Tawangan	Carrot	1
Naguey, Tawangan	Tiger grass	1

Effect Taro Leaf Blight and Taro Beetle on Yield

Reduction in yield. Majority (87%) of the taro growers claimed that yield decreased (Table 15) by 26-50% (Table 16) because of taro leaf blight even leading to zero corm yield compared to taro beetle where corm quality (holes and secondary rot) resulted to reduced yield. In Papua New Guinea, Solomon Islands and Vanuatu, the beetles are the main constraint to improving the yield and quality of taro production. According to the taro cash crop growers in Sablan, taro beetle damage result to poor corm quality but because of the high price of taro in the market, the damaged corms could still be sold in pre-sliced packs or used for household consumption after cutting off the damaged parts.

Table 15. Change in yield of taro due to taro leaf blight and taro beetle

BARANGAY	NO EFFECT	ZERO YIELD	DECRESED YIELD
	# of respondents		
Bayabas	1		6
Naguey	1		3
Cabiten			5
Tawangan		1	10
Taloy Sur			6
San Pascual	1		5
Basil			16
Besong			7
Amelong-Labeng			4
Kayapa Poblacion East			1
Total, n=71	**3**	**1**	**62**
%	**4**	**1**	**87**
x2 value	*1.314E2, p.000***		

Percentage reduction in yield. For the 36 taro growers (51%), reduction in yield ranges from 26-50 percent. Twenty growers (28%) claimed 51-75% yield reduction followed by 12 growers (17%) who claimed less than 25% yield reduction. Only 3 growers (4%) claimed 76-98 % decrease in yield. Damage caused by TLB and TB resulted to fewer leaves and stalk, thereby compromising photosynthesis causing the reduction of corm yield.

Table 16. Percentage decrease in yield of taro due to taro leaf blight and taro beetle

BARANGAY	PERCENTAGE DECREASE			
	25 & less	**26-50**	**51-75**	**76-98**
	# of respondents			
Bayabas	1	5	1	
Naguey	1	3		
Cabiten	3	1	4	
Tawangan	2	10		
Taloy Sur	1	2	3	
San Pascual	4			2
Basil		9	7	
Besong		5	2	
Amelong-Labeng		1	2	1
Kayapa Poblacion E.			1	
Total, n=71	**12**	**36**	**20**	**3**
%	**17**	**51**	**28**	**4**

*x2 value=1.388E2, p.033**

Association of yield and pest severity. There is a close association of the decrease in yield to leaf blight and beetle severity as shown by the contingency coefficient of 0.747 and 0.762, respectively. The results in Table 17 also show that the respondents observed reduction in yield regardless of severity whether mild, moderate or severe.

Reduced leaf area caused by TLB has frequently been associated with corm yield losses (Hunter & Puono, 1998). However, measuring TLB severity by percent disease may not always relate to yield (Cox, 1986). This is because healthier, resistant plants will retain more diseased leaves and have higher ratings and corm yield than susceptible plants. In the study by Gollifer and Brown (1974), no correlation was found between disease and yield but there was positive correlation between disease severity and number of leaves per plant and leaves of plant per corm yield. In addition, Brooks (2000) showed that there was no consistent correlation between disease severity and corm weight. The study further suggest that taller, more vigorous plants produced heavier corms than those that are shorter and less vigorous which signify that conditions promoting plant vigor has a greater effect on yield than TLB.

Table 17. Association of yield reduction to assessed TLB and to TB severity

SEVERITY	NO EFFECT	ZERO YIELD	DECRESED YIELD
TARO LEAF BLIGHT		# of respondents	
Mild			18
Moderate	3		27
Severe	3	1	18
*x^2 value, 93.394, p.000** Contingency coefficient=0.747*			
TARO BEETLE			
Mild	4		23
Moderate			20
Severe	3	1	20
*x^2 value, 1.025E2, p.000** Contingency coefficient=0.762*			

Factors Affecting Incidence and Severity of Taro Leaf Blight and Taro Beetle

Climate. As shown in Table 18, the wet months or during the rainy season from are more conducive to TLB and TB incidences. From 2013-2017, rainfall starting in April reached 141mm; the heavier rainfall from July to September showing a wide range from 368mm to 1,494mm per month which means a very variable rainfall pattern from year to year, and slowing down in October sometimes at a low of 107mm/mo to a high of 1,212 mm/mo (Part 1, Vol. 1). The variable rainfall or weather pattern is also the reason of respondents attributing incidence of diseases to rapid change in weather, climatic changes, high air temperature and too humid conditions. Other contributing factors relates to management practices on irrigation, weeding, planting and use of land. This association of climate to pest incidence is close at contingency coefficient of 0.854 and 0.802 for TLB and TB, respectively.

Table 18. Association of climate and field conditions to TLB and TB severity

CONDITION	LEAF BLIGHT SEVERITY			TARO BEETLE SEVERITY		
	MILD	MODERATE	SEVERE	MILD	MODERATE	SEVERE
	# of respondents					
Dry months	1		4	1		4
Wet months/ rain	5	16	9	10	13	7
Rapid change in weather		1				1
Climatic changes		1	2	1		2
Overhead irrigation		1			1	
Weedy		1			1	
Continuous planting		1			1	
High temperature			1			
Too humid		1				1
Overuse of land		1			1	1
Total, n=45	**6**	**23**	**16**	**12**	**17**	**16**
%	**13**	**51**	**36**	**26**	**38**	**36**

x^2 1.905E2, p.000 1.276E2, p.000 Contingency coefficient 0.854 0.802

The climatic condition in the selected root crop growing barangays is almost identical as shown in the geographical coordinates, elevation, temperature and rainfall (Table 19).

Table 19. Coordinates, elevation, temperature and rainfall of study sites

BARANGAY	COORDINATES		ALTITUDE (m)	MEAN TEMP (^{0}C)	MEAN RAINFALL (mm)
	LATITUDE	LONGITUDE			
BENGUET					
Basil	16.5126	120.6192	820.8		
Bayabas	16.4686	120.4894	685.7		
Cabiten	16.8943	120.7545	765.4		
Naguey	16.5871	120.6608	1149.3	20.8	2487
San Pascual	16.4018	120.4947	658.8	20.4	2896
Taloy Sur	16.3618	120.5193	867.4	20.4	2896
Tawangan	16.6551	120.875	2195		
NUEVA VIZCAYA					
Amelong-Labeng	16.3231	120.9167	891	21.3	2616
Besong	16.3402	120.8829	1350.8		
Kayapa Poblacion East	16.5959	120.9012	1487.3		

Source: https://www.philatlas.com

Planting and harvesting time. According to majority of the taro growers, planting and harvesting time could be done regardless of season whether the wet months (April–October) or dry months (November– March) as shown in Table 20. In Benguet and Nueva Vizcaya, taro has a maturity period of 6-7 months (Gayao, Meldoz and Backian, 2013; Gayao, et al, 2014). Taro beetle infestation is also observed at 3-5 MAP in both seasons. The beetle starts to feed on the leaves, then burrows through the stalks and moves down to the base then to the developing corms. The rainy season, on the other hand is conducive for TLB infection.

In Cordon, Nueva Vizcaya farmers harvest taro for vegetable use at 3-4 months from planting. The farmers in Naguey, Atok, and in San Pascual, Tuba start planting during the wet months in rainfed paddies and in swidden fields, respectively. When planted in Bayabas, Sablan, taro cash crop is usually planted from November – February (dry months) in rotation to rice crop planted at the onset of the rainy season. In Cabiten, Mankayan; Tawangan, Kabayan; Basil, Tublay; and Taloy Sur, Tuba, taro is planted anytime of the year. Whatever is planted during the wet season will be harvested during the dry season, and vice versa. However, for household use, once the taro is big enough for use as vegetable, harvesting is started at 3MAP until its senescence after one year or more depending on favorable conditions e.g. no pests and diseases.

Table 20. Planting and harvesting time of taro in Benguet and Nueva Vizcaya

BARANGAY	PLANTING TIME			HARVESTING TIME		
	Wet Months	Dry Months	Wet/Dry Months	Wet Months	Dry Months	Wet/Dry Months
Bayabas	0	4	2	3	0	3
Naguey	3	0	1	0	3	1
San Pascual	3	2	1	3	3	0
Cordon	0	0	1		(after 3-4 mos)	
Cabiten	0	0	8	0	0	8
Tawangan	0	1	11	1	0	11
Basil	0	7	9	7	0	9
Taloy Sur	2	1	3	1	2	3
Besong			7	0	0	7
Amelong-Labeng			4	0	0	4
Kayapa PE			1	0	0	1
Total, n=71	**8**	**15**	**48**	**15**	**8**	**47**
%	**11**	**21**	**67**	**21**	**11**	**67**

Planting materials. Most of the respondents either use cormels, suckers/runners and corm heads which they saved from their previous crop (92%) even after being infected or infested by TLB and TB, respectively (Table 21). Consequently, the farmer's own planting materials could be carriers of the pests.

Table 21. Source of planting materials before and after occurrence of taro leaf blight and taro beetle in Benguet and Nueva Vizcaya

BARANGAY	OWN CROP		FROM OTHERS	
	BEFORE	AFTER	BEFORE	AFTER
Bayabas	8	7	2	2
Naguey	4	4		
Cabiten	6	6	6	6
Tawangan	9	9	7	7
Taloy Sur	6	5	3	3
San Pascual	5	5	1	1
Basil	15	15	1	1
Besong	7	7		
Amelong-Labeng	4	4		
Kayapa Poblacion East	1	1		
Total, n=71	**65**	**63**	**20**	**20**
%	**92**	**89**	**28**	**28**
multiple response				
x^2 value, before and after	*1.531E2, p.000***		*1.506E2, p.000***	

Varieties. There were thirty-six (36) old and new varieties of taro documented by Gayao, Meldoz and Backian (2013) in Tuba, Benguet. In this study, the taro growers identified six (6) varieties which they cultivate. The four (4) varieties were identified as Chinese/'*Itchina*', Mindanao, '*Dem-an*' and Violet/'*Subok*'. '*Itchina*' while the other two (2) are referred to as native or old varieties and new varieties.

Gonzales et al. (2008) have recommended Chinese/*Itchina*, *Mindanao*, PRG 396, PRG 377, PRG 382 and PSBG-5 for highland production because of their high yield, resistance to pests and disease and good eating quality. They further indicated the high preference of farmers for *Itchina* and Mindanao varieties for commercial production as was the case in this study. However, during the interview, more respondents argued that *Itchina*, *Dem-an* and Violet/ *Subok* are susceptible to TLB and TB but were divided as to the tolerance or susceptibility of Mindanao and the native varieties (Table 22).

From 2000 to 2007, the Philippine Root Crops Research and Training Center (PhilRootcrops) have released the *gabi* varieties PSB-G-4, PSBG-5, VG-1 (*Kalpao*), VG2 (*Iniito*), VG-3 (*Dalwangan*), NSIC G-6, NSIC G-7, NSIC G-8, NSIC G-9 and NSIC G-10 whose characteristics include corm yield ranging from 5.24 t/ha to 11.74 t/ha, dry matter content of 33.68% to 45.42% and resistance to leaf blight (PNS/BAFS, 2014). As farmers do not seem to be aware of these varieties, there is a need to increase efforts on introducing and making it available for highland farmers to assess as well as test for processor/consumer acceptability.

Table 22. Varieties observed by growers to be tolerant or susceptible to taro leaf blight and taro beetle

VARIETY	# OF RESPONDENT	
	TOLERANT	**SUSCEPTIBLE**
Chinese/Itchina	13	32
Mindanao	18	16
Dem-an		1
Violet/Subok		3
Native/ old varieties	13	14
New varieties	1	1
Total- all sites	**45**	**64**

Fertilizer and pesticide use. As shown in Table 23, fertilizer and pesticide use highly differed among taro growers in the different barangays with majority not applying fertilizers (52%) and not spraying pesticides (78%). The 31% who applied NPK inorganic fertilizer and 7% who sprayed insecticide and fungicide were noted in areas that grow taro as cash crop such as in Bayabas, Sablan and Naguey, Atok. Taro planted for home consumption is usually not sprayed.

Table 23. Pesticide and fertilizer use for taro crop among growers in Benguet and Nueva Vizcaya

BARANGAY	PESTICIDE USE				FERTILIZER USE			
	None	Insecti-cide	Fungi-cide	Insect / Fungi	None	Inorganic (NPK)	Organic	Organic/ Inorganic
	# of respondents							
Bayabas	4			3	1	6	5	
Naguey			1	1		2		1
Cabiten	6	1				2	1	5
Tawangan	11	1			12			
Taloy Sur	6				4	1	1	
San Pascual	1	1	3	1	1	4		1
Basil	16				7	7	1	1
Besong	7				7			
Amelong-Labeng	4				4			
Kayapa Poblacion East	1				1			
Total, n=71	**55**	**3**	**4**	**5**	**37**	**22**	**8**	**8**
%	**78**	**4**	**6**	**7**	**52**	**31**	**11**	**11**
x^2 value		*1.517E2, p.000***				*2.022E2, p.000***		

Even with very few growers who are using pesticides and fertilizers in their taro crop, their association to TLB and TB severity is close at contingency coefficients that ranges from 0.752 to 0.796 (Table 24). More farmers spray pesticides during moderate to severe incidence of TLB and during mild to moderate incidence of TB.

Table 24. Association of pesticide and fertilizer use to TLB and TB incidence

BARANGAY	PESTICIDE USE				FERTILIZER USE			
	None	**Insecti-cide**	**Fungicide**	**Insect/ Fungi**	**None**	**Inorganic (NPK)**	**Organic**	**Organic/ Inorganic**
TARO LEAF BLIGHT				# of respondents				
Mild	8		1	1	4	2	1	3
Moderate	23			5	14	8		6
Severe	14							
Contingency coefficient		*0.752, p.000***				*0.796, p.000***		
TARO BEETLE				# of respondent				
Mild	12		3	2	9	4		4
Moderate	15	1	1	5	6	9	2	5
Severe	18	2			10	3	2	5
Contingency coefficient		*0.759, p.000***				*0.785, p.000***		

Pest management practices and coping mechanisms. Majority of the taro growers do not have good agricultural practices in TLB and TB management (they just leave infected plants in the farm), probably because there is also lack of research and extension services to address these problems. What they do with pests damaged plant or corm is to clean or remove infected parts and utilize them (Table 25). This is a pragmatic practice but just the same will contribute to the spread and not eradication considering the nature of the taro leaf blight causing fungus and the wide host of taro beetle as evidence by the close association of management practice to disease severity (contingency coefficient of 0.851 and 0.759, respectively). There is however very few farmers who does commendable prevention and control practices but sadly outnumbered.

Table 25. Pests management practices and their association to TLB and TB incidence

PEST MANAGEMENT	LEAF BLIGHT SEVERITY				TARO BEETLE SEVERITY			
	MILD	MOD.	SEV.	TOTAL	MILD	MOD.	SEV.	TOTAL
None/ just leave in the field		13	8	21	14	14	10	38
Uproot and throw	2			2	1	1		2
Clean corm and utilize and trimmings left in the farm	4	10	4	18	1	2	4	7
Abandon and transfer to other area	1	2	1	4	3			3
Spray	2	1	4	7	1	3	5	9
Burn and bury			1	1				0
Replace variety			2	2				0
Adjust time of planting	1		1	2				0
Manually remove pests/ damaged part		1						0
Total	**10**	**27**	**21**	**58**	**20**	**20**	**19**	**59**
%	**17**	**47**	**36**	**100**	**34**	**34**	**32**	**100**

*x^2value 1.862E2, p.000** 96.651, p.000** Contingency coefficient 0.851 0.759*

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Taro growers are farmers with multiple crops and multiple sources of household income. Taro is just one to the mixed crops planted in swiddens, paddies, vegetables and backyard gardens, as intercrops, border crops, rotation crop or mono crop. Farm areas planted are small mostly for home consumption and some as cash crop.

There are 13 pests affecting taro but taro leaf blight (TLB) and taro beetle (TB) were identified by 100% and 89% of respondents, restively as the most damaging. The others were rot, rust or *date*, cutworm or *rimas/dimas*, hornworn or *ataro,* white fly and aphid (*aplat*), white grub (*hapiloy/balikutkot/loklok*), hopper, snail (*kuhol*), beetle (*tolbing*) and others locally known as *kawaweng/kawatang, safidol* and *batungol/arabas/dangaw/shangew*.

Assessed percentage incidence and severity rating highly differed among the growers in the selected barangays with 28% and 31% claiming 70-100% incidence or severe rating. Forty-two percent of respondents rated moderate severity at 40-69% incidence; and 27% of growers rating severity as mild at 5-39% TLB incidence. Sixteen percent of growers assessed 70-100 % incidence and severe rating of 38% on TB, with more (48%) claiming 40-69% incidence or moderate severity, and 38% of growers rating severity as mild with 5-39% incidence.

Majority of the growers claimed that corm yield decreased regardless of severity rating because of smaller corms, or poor corm quality and zero yields. Other crops of the growers like tannia, tomato, beans, cabbage, potato, pechay, eggplant and others are also affected with the TLB symptoms and TB damages.

Climatic changes, crop management practices like irrigation, weeding, planting, fertilization, pesticide use, land use, planting materials, varieties and pest management practices are factors that influenced occurrence and severity of TLB and TB.

Considering farm area planted and purpose of taro crop, the many hosts and plants affected by TLB and TB, the nature of the TLB-causing fungus that remains in the soil for a long time, and the life cycle of the TB that coincides with the growing stage of taro, are all important information in developing pest management strategies. Like breeding/ evaluating resistant varieties and developing integrated pest management program that coincides with the area, purpose and cropping system of the taro farmers. In addition, since the study revealed that the symptoms of the disease have been observed across the major taro growing areas in Benguet and Nueva Vizcaya, there should be continuous monitoring and surveillance of concerned stakeholders to map affected areas to minimize spread of infected planting materials as well as distribution of clean planting materials.

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YAM ANTHRACNOSE (*Colletotrichum gloeosporioides*) AND OTHER YAM INSECT PESTS AND DISEASES AFFECTING FARMS OF INDIGENOUS GROWERS IN BENGUET AND NUEVA VIZCAYA, PHILIPPINES

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ABSTRACT

The inadequacy of knowledge on insect pests and diseases particularly anthracnose affecting yam farms production output, and quality of planting materials prompted this study. The research documented the farmers' knowledge on the extent of the disease and the management of yam anthracnose in the context of the yam growers' farm and household environment.

Most of the yam growing households are managed and maintain by the wife of the farmer. The utilization of swidden or *uma* is the common practice for yam farming. Swidden farm area operated is usually $500m^2$ to $1000m^2$. Mixed cropping and intercropping of cash crop with yam is done to maximize the area and to support the farmers' basic needs.

Seventy-six (76) percent of the yam growers observed symptoms of anthracnose in the yam crop but highly differed among the growers in the different barangays. Forty-one percent of growers observed 10 - 35% incidence; followed by 24% of growers observing zero incidence; 16% observed 40 - 69% incidence; 6% observed 70 - 80% incidence; and 12% of growers observed 100% yam anthracnose incidence. Fifty-seven percent of the growers rated severity as mild, 20% as moderate and 23% as severe. The occurrence of the infections increased during the wet season, 4-5 MAP starting from the leaf extending to the leaf base and vine when severe. Fifty-one percent of the growers claimed yield decrease ranging from 26-50%, and only two percent of the growers claimed 100% yield decrease. Multiple infection and other insect pest damages was also observed but the damaged was noted to be minimal and can be tolerated by the crops until full maturity.

Farm environment factors that are associated with the occurrence of the disease in this study were climate, planting time, harvest period, source of planting materials, fertilizer and pesticide use and anthracnose disease management practice.

INTRODUCTION

Indigenous growers of yam in Benguet and Nueva Viscaya are burdened by the decision to plant yam to meet commercial demand, or to just plant few because of plant diseases and lack of planting materials. While plant diseases, like anthracnose and limited seeds are the alleged causes of low yam production until now no study was done to document the occurrence of yam anthracnose.

Yam is one of the important root crops in the market industry especially the purple yam (*Dioscorea alata*). Thus, the crop is considered one of the important export banner crops. One additional market value is the presence of natural purple anthocyanin pigment which is excellent as healthful antioxidants as stated by Salda V.B et al. (2005). However, there is limited source of disease-free planting materials caused by prevalent pest and disease problems like the yam anthracnose.

Yam anthracnose (*Colletotrichum gloesporiodes*) is the most popular and widespread foliar disease of yam. Yam anthracnose has been reported on almost all cultivated species of yam in the humid and sub-humid tropics. In Caribbean, susceptible cultivars of *D. alata* on a commercial scale favor the spread of the disease causing high yield losses by 50-90% (Mignucci J.S. et al., 1988). The use of chemicals to control the disease in a commercial scale could have an adverse effect to the environment. More over this will be an additional burden to the cost of production incurred by the farmer.

The fungi *Collectotricum* spp.is responsible for most anthracnose diseases, most abundant in the tropics and sub-tropics and which often has prolonged latent stage. Anthracnose is disease of the foliage, stems, or fruits that typically appear as dark-colored spots or sunken lesions with a slightly raised rim. At first, anthracnose generally appears on leaves as small and irregular yellow, brown, dark-brown or black spots that can expand and merges to affect whole leaf or affected area. Defoliation and dieback of the entire plant, orange-brown tuber rots, and small blisters appear on the tuber surface. The diseases are favored by wet, humid and warm conditions spread by infected plant material, seed tubers, mechanical means, rain splash and moist wind. Anthracnose affects many crops like yam, avocado, bananas, mangos, beans, cassava, cowpea, onions, tomato and citrus plants such that these are also hosts plants of the fungus It has long survival ability on crop residues as a saprophyte (ProMED, 2014; https://www.infonet-biovision.org, 2019).

Preventive management strategies provided by the local government and other research institutions are hard to come. This could be attributed to the very limited knowledge of local research and development service providers on crop losses due to yam anthracnose. This study documented the incidence and severity of anthracnose as observed by the yam growers in their farm and household environment.

METHODOLOGY

Selection of Sites and Respondents

The selected yam growing areas are based on secondary information gathered from provincial and municipal agriculture offices and market outlets. Seven barangays in four municipalities, namely: Sablan, Tuba and Tublay in Benguet and the municipality of Bambang in Nueva Vizcaya were selected. Tuba and Sablan respondents grow yam primarily for the market while respondents in Tublay and Bambang grow yam primarily for household food. There were 49 respondents consisting of 36 females and 13 males (Table 1). They were interviewed as a group and individual interview was done to clarify the information given by the participant during the informal workshop. The reason for the group interview was explained first. Description of yam farms including farming practices on yam were individually filled-up by the participants sometimes assisted by the researchers using an open-ended questionnaire as guide. This was followed with a group interview where discussions on pests observed in their yam crops particularly on the yam anthracnose complex. A picture of yam anthracnose signs and symptoms was shown and the participants shared information on when the yam anthracnose or other pests infesting the yam crop became visible, what parts of the plant and varieties were infected, severity of the pest and disease and coping mechanisms which were all recorded in the questionnaires. Samples of diseased yam parts were also collected for proper identification.

Table 1. Number of respondents in the barangays and municipalities selected in Benguet and Nueva Vizcaya, Philippines

MUNICIPALITY	BARANGAY	# OF RESPONDENTS		
		MALE	FEMALE	TOTAL
Sablan	Bayabas Kamog	4	2	6
Tuba	Taloy Norte Taloy Sur San Pascual	6	23	29
Tublay	Basil	0	9	9
Bambang	Pallas	3	2	5
TOTAL		13	36	49

Data Analysis

Data from the questionnaires were encoded in the Excel software and analyzed using the SPSS software. Descriptive analysis using cross-tabulation, Pearson chi-square and contingency coefficient correlation, if applicable were done. Level of significance was set at five percent.

Assessment of yam anthracnose incidence and severity. Assessment of plant disease intensity is an important information prior to further studies on the prevention and control of pests and diseases. Intensity is expressed in terms of incidence, i.e., the number or proportion of diseased plants in a population, and severity, i.e., the area or proportion of plant tissue that is symptomatic (Campbell and Heher, 1994) According to Dr. Sharma (2019), disease incidence could be the percentage of diseased leaves or stalk in a plant or diseased plants in a field while disease severity is the percentage of relevant host tissues or organ damaged by the disease.

In this study however, the presence of the disease in the farmers' field was first determined as follows:

The percentage of farmers who observed yam anthracnose in their farms was referred to as **Perceived Incidence** and was assessed using the following formula:

$$\textbf{Perceived anthracnose incidence} = \frac{\text{Number of farmers who observed yam anthracnose}}{\text{Total number of yam growers interviewed}} \times 100$$

Disease incidence assessed from the viewpoint of the researchers was determined as follows:

$$\textbf{Percentage Incidence} = \frac{\text{Number of plant/hills with observed infection}}{\text{Total number of plants or hills}} \times 100$$

Severity based by the yam growers on harvested yam tubers was assessed on a scale of 1-5 where:

Scale	Description
1	Mild (at least 75% of crop was harvested)
3	Moderate (40-60% of crop was harvested)
5	Severe (at least 25% of crop was harvested)

Laboratory Analysis. During the field visit and monitoring infected leaf and tubers were collected. The advancing portion of the infected collected plant samples was disinfected, cut into small square shape and incubated for 3 to 5 days in a moist chamber to enhance the growth of the pathogen. After the incubation period, the pathogen was isolated from the infected leaf/ tuber samples and grown in potato dextrose agar medium after sterilizing. After a week, the growth of the fungus was examined under the microscope for fungal bodies confirmation on the causal organism.

RESULTS AND DISCUSSION

In order to make useful recommendations to prevent and/or to remedy critical outbreak of yam anthracnose disease, incidence and severity must be within the context of who the yam farmers are and how the yam plants are grown.

Characteristics of Yam Farming Households

Majority (96%) of the yam growers source their cash income from crop sales as shown in Table 2 with 47% of household members getting salaries as employees or wages as laborers. Twenty seven percent are engaged in retail store, agricultural crop assemblers or public transport businesses. Others (31%) receive cash allowance as barangay officials or volunteers and/ or receive cash assistance from social services (Table 2). Yam growers also source out their food from multiple sources: 98% from own produce, 96% from purchases within or outside the locality and 35% from other sources like gifts from other farmers or neighbors (Gayao et al., 2019).

Table 2. Major crops planted in the study areas

MUNICIPALITY	MAJOR CROPS PLANTED
Sablan	Fruit including pineapple, root crops like sweetpotato, yam and taro
Tuba	Fruit trees including lemon, sweetpotato, yam and taro
Tublay	Chayote, rice, beans and anthurium
Bambang	Rice and corn; ginger, onions and garlic; tomatoes, squash, eggplant; sweetpotato, tannia and cassava, fruits like coconut and mango

Source: Part 1, Vol. 1

Description of Yam Farms

Most (98%) of the respondents plant in "*uma*" or swidden farms in hills or mountain slopes, and 49% plant in parts of backyard near trees or in borders of vegetable gardens (Table 3).

Table 3. Types of farm operated by yam household growers

BARANGAY	*UMA/* SWIDDEN	*TALON/* RICE FIELD	GARDEN	BACKYARD GARDEN
	# of farmers			
Bayabas	4		3	3
Kamog	2			2
Taloy Norte	9	1		1
Taloy Sur	6	2	3	6
San Pascual	13	7		7
Basil	9	7	3	4
Pallas	5		1	1
Total, n=49	**48**	**17**	**10**	**24**
%	**98**	**35**	**20**	**49**

**multiple response*
*x^2value=75.297 p.000***

Swidden farming in the Philippines is usually family operated, most likely farm sizes ranging from 500m^2 and below to suit available family labor. For vegetable gardens (1000m^2 – 5000m^2), areas operated depend on sufficiency of water for irrigation. Rice fields are located in lower terraced slopes usually near rivers or water source (Table 4).

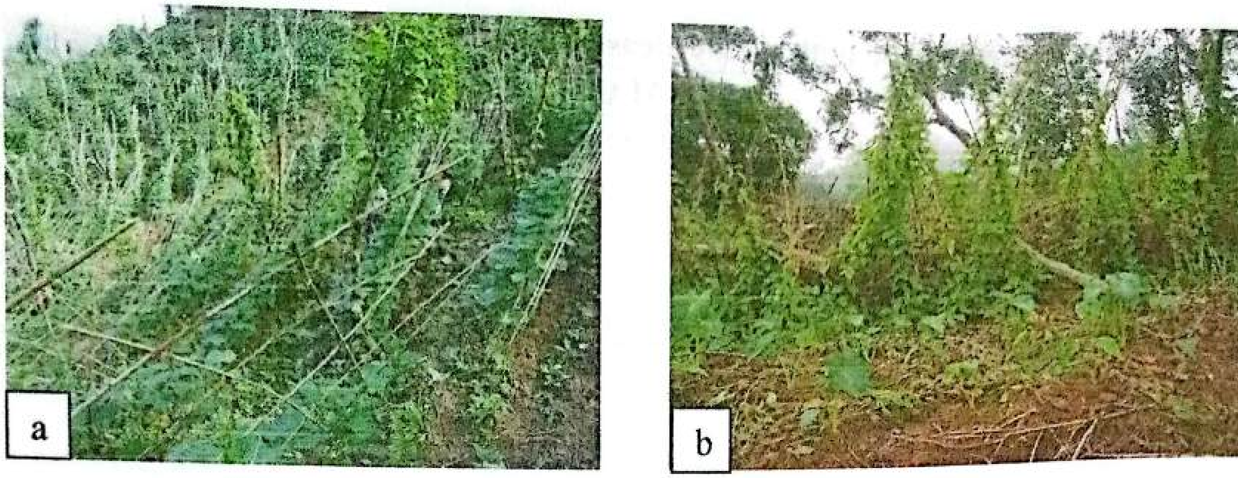

Fig. 1. Yam production in *uma* (a) Taloy Norte, (b) Taloy, Sur both in Tuba, Benguet

Table 4. Total farm sizes operated by yam growers

BARANGAY	500SQM and BELOW	>500 to 1000SQM	>1000 to 0.5HA	>0.5HA to 1 HA	>1 HA
	# of farmers				
Bayabas	1		2		1
Kamog			1	1	
Taloy Norte		7		1	
Taloy Sur		2	2	2	
San Pascual	3		3	2	6
Basil	3	3	3		
Pallas			3	2	
Total, n=48	**7**	**12**	**14**	**8**	**7**
%	**14**	**25**	**30**	**17**	**14**

*x^2value= 61.170, p.006***

Only the respondents in Taloy Sur and San Pascual plant yam as the main crop or a cash crop. Majority of the growers (98%) consider yam as just one of the mixed crops or intercrops planted in addition to rice, other root crops, vegetables and legumes, tiger grass, etc. (Table 5). Thus, banana, tannia, taro, ginger, winged beans, lima beans and lesser yam were also observed to show symptoms of the yam anthracnose disease like yellowing, blackening of the stems and leaves and die back of the plant confirming observations in literatures cited. (ProMED, 2014; https://www.infonet-biovision.org., 2019).

Table 5. Cropping systems and cropping patterns practiced by growers

BARANGAY	MONO-CROPPING	MIXED CROPING	MAIN / ROTATION CROP	INTER CROP	BORDER CROP
	# of farmers				
Bayabas		4		4	4
Kamog	1	2		2	
Taloy Norte		9		9	
Taloy Sur	1	6	2	6	1
San Pascual	1	13	2	12	
Basil		9		1	8
Pallas		5		5	
Total, n=49	**3**	**48**	**4**	**39**	**13**
%	**6**	**98**	**8**	**80**	**27**

**multiple response*

Description of the Anthracnose Disease

Anthracnose is one of the most serious diseases affecting yam and is a limiting factor for production of these crops worldwide (Pro-MED, 2010). It is caused by the fungus *Colletotrichum gloeosporioides* and the disease affects leaves, vines and tubers. The fungus has long saprophytic survival ability on crop residues (ProMED, 2014) hence, once a crop is infected, it will take 2-3 years to recover as claimed by a farmer in Palawan, Philippines (Abello, 2010).

Plant parts infected. The plant parts that are commonly affected are the leaves and vine especially near the base regardless of the variety and season of planting as presented in Table 6. According to the respondents, very small brown spots initially appear on young leaves and tender parts of the plant expanding to yellowish, brown/black leaf lesions, necrosis, defoliation and dieback of the entire leaf. Severe infection may affect the vine/ stem. Symptoms in the tubers are rots and small blisters on the tuber surface were observed.

Table 6. Plant parts where yam anthracnose symptoms appear

BARANGAY	PLANT PARTS			
	VINES/LEAF BASE	LEAVES	LEAVES/VINES /LEAF BASE	WHOLE PLANT
	# of farmers			
Bayabas	4	0	0	0
Taloy Norte	0	0	6	2
San Pascual	0	5	6	0
Pallas	5	0	0	0
Basil	0	0	0	0
Taloy Sur	0	0	6	0
Kamog	0	0	2	0
Total,n=36	**9**	**5**	**20**	**2**
%	**25**	**14**	**56**	**5**

*x^2=1.009E2, p.000***

Laboratory analysis. Confirmatory test of the fungal pathogen from the collected infected plants that was cultured in potato dextrose agar medium proved that the infection was caused by *Colletotrichum* spp. (Figure 1). Maximum radial growth of the fungus was similar in malt extract sugar and oat meal agar medium (Devanshu, Somasekhara and Pranasannakumar, 2017).

Figure 1. a.) Infected leaves, b.) Fungal spores

Stages of infection. Yam undergoes the stages of tuber sprouting (prior to planting), vegetative growth (when planted) and tuber dormancy (when matured/ harvested). During the vegetative stage, the shoot emerges, the root system develops, then the vines and leaves develop one month after emergence. Tuber development begins around 11-13 weeks after plant emergence (Schuster, 2019).

The onset of the disease was commonly observed two to four months after planting (MAP) during the vegetative stage just after plant emergence until tuber bulking (Table 7).

Table 7. Plant stage when yam anthracnose infection appears

BARANGAY	NO DISEASE	STAGE		
		2-3 MAP	3-4 MAP	AT BULKING
	# of farmers			
Bayabas	0	4	0	0
Taloy Norte	2	3	3	0
San Pascual	3	1	7	1
Pallas	0	5	0	0
Basil	9	0	0	0
Taloy Sur	0	1	5	0
Kamog	0	0	0	2
Total, n=46	**14**	**14**	**15**	**3**
%	**30**	**30**	**33**	**7**

*x^2=90.965, p.000***

This could mean that the tuber planting material is already a carrier of the fungus. At 2-3 MAP, 12 farmers observed the appearance of anthracnose symptoms at the plant base (vines and leaves) while another 9 farmers observed appearance of the symptoms at 3-4 MAP (Table 8). At this critical tuber bulking stage the tuber yield is already compromised.

Table 8. Relationship of plant parts affected to plant stage

STAGE	PLANT PARTS AFFECTED		
	VINES/LEAF BASE	LEAVES	VINES/LEAVES/BASE
1 MAP	0	0	1
2 to 3 MAP	9	0	3
3 to 4 MAP	0	0	9
At bulking	0	1	1

*x^2= 81.200, p.000**   Contingency coefficient 0.790*

Incidence and Severity of Yam Anthracnose

Incidence. Based on the total number of farms, yam anthracnose incidence or occurrence was noted in 76% of the growers' farm or yam crop (Table 9). These are the growers in San Pascual, some growers in Taloy Norte and Taloy Sur in Tuba, and in Bayabas and Kamog in Sablan, Benguet; and in Pallas, Bambang, Nueva Vizcaya. This observation highly differed (p.000) among growers in the different barangays with 24% of growers observing zero incidence particularly in Basil, Tublay and some in Taloy Norte, Tuba. The isolated location of the yam farm areas in Basil, Tublay and some parts of Taloy Norte, Tuba may play a role in the zero infection of anthracnose. Wherein yam farms has no exposure to visitors and has limited access on commercial yam seed that may carry the plant disease.

Table 9. Number of yam farms/ growers with observed incidence of anthracnose

BARANGAY	# (%) OF RESPONDENTS	
	OBSERVED INCIDENCE	NO INCIDENCE
Bayabas	4	
Kamog	2	
Taloy Norte	6	3
Taloy Sur	6	
San Pascual	14	
Basil		9
Pallas	5	
Total, n=49	**37**	**12**
%	**76**	**24**
x^2 value	*38.185, p.000***	

Percentage incidence and severity. Most growers (41%) assessed 10-35% percentage incidence based on a plant population of 10 hills; 16% of growers assessed 40-69% incidence, 6% assessed 70-80% incidence, and 12% of the yam growers in Tuba (San Pascual, Taloy Sur and Taloy Norte) assessed 100% incidence (Table 10). In was in Taloy Sur where a widespread anthracnose attack was recorded in 1991. According to ProMED (2014), the fungus causing anthracnose has long saprophytic survival ability on crop residues even in other host plants. It is only in Basil, Tublay where yam is grown only for home use that zero infection were noted.

In assessing severity of the disease, 57% of the grower-respondents rated yam anthracnose disease as mild when three-fourth of the of the crop yield could be harvested; 20% as moderate or at least one-half is harvestable; and 23% as severe when only 25% or less is harvestable.

Table 10. Incidence and severity of yam anthracnose observed by farmers in selected barangays in Benguet and Nueva Vizcaya

BARANGAY	% INCIDENCE					SEVERITY RATING		
	0	10-35	40-69	70-80	100	Mild	Moderate	Severe
Bayabas		4				4		
Kamog		2				2		
Taloy Norte	3	4			2	7		2
Taloy Sur		2	1	2	1	2	1	3
San Pascual		8	2	1	3	4	4	6
Basil	9							
Pallas			5				5	
Total, n=49	**12**	**20**	**8**	**3**	**6**	**28**	**10**	**11**
%	**24**	**41**	**16**	**6**	**12**	**57**	**20**	**23**
x^2 value	*1835E2, p.000***					*97.042, p.000***		

Other Yam Insect Pests and Diseases

Multiple infection and insect pest damages were also observed in yam crops. Fusarium infection (12%) was observed in Taloy Norte. Moreover, Nwankiti and Arene (2009) reported that wilt diseases incited by *Fusarium oxysporum* and *Sclerotium rolfsii* may cause premature death of 45–70% of the crop. Tuber rotting (10%) was also noted in Taloy Sur and San Pascual. Insect pest damages (2%) were noted to be minimal and can be tolerated by the crops until full maturity as presented in Table 11. *Fusarium*, tuber rotting, leaf blight and aphids were rated by the farmers with high percentage incidence or severe. Aphid infestation was observed during the summer months. Aphids may transmit virus infection which affects the health of the incoming seed setts for the next cropping season. Although no virus symptoms were observed among the plants during that period.

Table 11. Yam insect pests and diseases affecting yam crops in selected barangays in Benguet and Nueva Vizcaya

PESTS	**# OF RESPONDENTS**								
Common (Local) Name	**Bayabas**	**Kamog**	**Taloy Norte**	**Taloy Sur**	**San Pascual**	**Basil**	**Pallas**	**Total**	**%, n=49**
Anthracnose	4	2	6	6	14		5	**37**	**76**
Fusarium			5				1	**6**	**12**
Tuber Rotting				3	2			**5**	**10**
Hornworm (*Ataro*)	1							**1**	**2**
(*Sipsip*)	1							**1**	**2**
(*Kateket*)			1					**1**	**2**
Cutworm			1					**1**	**2**
Leaf Blight					1			**1**	**2**
(*Dangao*)					1			**1**	**2**
Whiteflies					1			**1**	**2**
Aphids					1			**1**	**2**
Leaf spot					1			**1**	**2**

Effect of Anthracnose and Other Pests on Yield

The decrease in yam yield cannot be solely due to anthracnose infection as there are other pests that damage the crop and also other probable causes. However, 70% of the growers claimed that their yield significantly decreased. The number of tubers decreased with smaller size than the usual harvest and only 30% claimed that the anthracnose has no effect on their yield particularly from Barangay Bayabas, Basil, San Pascual and Taloy Norte (Table 12). The farmers (34) who claimed decreased yield observed mild to severe yam infection but there were also 15 farmers who observed no decrease in yield despite experiencing mild to moderate disease severity. This is due to the fact that their crops were tolerant and mostly infected towards maturity stage, hence most of the plants has developed tubers already. Thus, the association of disease severity to decrease in yield is not perfect as shown by the contingency coefficient of 0.590.

Table 12. Effect of anthracnose on yield and association of disease severity to yam yield

BARANGAY	NO DECREASE	DECREASED YIELD
	# of farmers	
Bayabas	3	1
Kamog		2
Taloy Norte	1	8
Taloy Sur		6
San Pascual	2	12
Basil	9	
Pallas		5
Total, n=59	**15**	**34**
x^2 value	*46.431, p.000***	
SEVERITY RATING		
Mild	14	14
Moderate	1	9
Severe		11
Total, n=49	**15**	**34**
%	**30**	**70**
x^2 value	*26.198, p.003***	
Contingency coefficient	*0.590, p.003***	

Percentage decrease in tuber yield. The decrease in yield highly differed among growers in the different barangays but only one grower in Taloy Sur claimed 100% decrease; while majority of the growers (51%) claimed to have only 26-50% yield decrease; 10% reported 51-75 % decrease; and 37% reported 0-25% decrease in yield (Table 13). In a study conducted by Kolade et al. (2018), yam anthracnose disease (YAD) can cause up to 80% yield loss where it is endemic. Loss of leaves due to anthracnose infection also reduces photosynthesis that leads to undersized yams. Sinclair et. al., 2004 stated that in these circumstances, a 33% increase in leaf photosynthesis may translate into an 18% increase in biomass and only a 5% increase in grain yield, or a −6% change in grain yield in the absence of additional nitrogen.

Table 13. Percentage decrease in yield of yam due to anthracnose

BARANGAY	PERCENTAGE DECREASE			
	0-25	26-50	51-75	76-100
	# of farmers			
Bayabas	3		1	
Kamog	1	1		
Taloy Norte	2	7		
Taloy Sur		1	4	1
San Pascual	3	11		
Basil	9			
Pallas		5		
Total, n=49	**18**	**25**	**5**	**1**
%	**37**	**51**	**10**	**2**

*x^2 value 1.181E2, p.000***

Factors Affecting Incidence and Severity of Yam Anthracnose

Climate. Benguet and Nueva Vizcaya, Philippines had two distinct seasons, the wet or rainy season from May to October and the dry season from November to April. Wet, humid and warm conditions favor the growth of yam anthracnose. This association of climate to anthracnose infection is quite close as evidence by the contingency coefficient of 0.613. The fungus is spread mainly by infected plant material, seed tubers, mechanical means and splashing rain. These observed symptoms vary according to the vegetative stage of the plant, weather condition and the variety of yam. Prolonged rain aids in the spread of the spores leading to epidemics if untreated. This was proven when severe yam anthracnose epidemic was experienced by the yam farmers in Tuba, Benguet during a month of continuous rain in August 1991, just a month after the Mount Pinatubo volcanic eruption in July (HADFI-DARDRDAP Annual Report, 1991). As shown in Table 14, 58% of the farmers observed mild to severe infection during the wet season, as compared to only 4% observing the disease during the dry season.

Table 14. Association of yam anthracnose severity to climatic conditions

CLIMATIC CONDITION	# OF FARMERS				%
	SEVERITY				
	MILD	MODERATE	SEVERE	TOTAL	
Dry season	1	0	0	1	**4**
Wet season	5	4	6	15	**58**
Climate change	4	0	2	6	**23**
Volcanic dust	1	0	0	1	**4**
Soil and Air borne	0	0	3	3	**11**
Total	**11**	**4**	**11**	**26**	**100**

x^2=29.484, p.079^{ns} Contingency coefficient =0 .613

Rain splash and moist wind contributes in the spread and severity of the disease causing 58% severity as usually observed during the wet season. Another 23% of farmers attributed climate to the increase in disease infection since sometimes rain comes late or too early.

Planting time. The planting season for yam greatly varies according to the availability of irrigation water. Most of the yam growers who depend on rain for irrigation usually plant during the onset of wet season from April to June. The incidence and severity of anthracnose infection is commonly observed during the wet season. As shown in Table 15, 70 % of the infection as observed by the growers was noted during the wet season. Severity rating showed no significant differences though contingency coefficient of 0.466 shows some association of planting time to severity of disease. Disease infection at tuber bulking stage which are usually visible at 4-5 MAP was more severe in areas of higher rainfall (Sweetmore, et al., 1994). Disease predominated on young leaves on severe epidemics. Moreover combined with the typhoons passing through the country, this greatly contributes to the decreased in yield.

Table 15. Association of yam anthracnose severity and planting time

PLANTING TIME	SEVERITY			Total	%
	Mild	Moderate	Severe		
	# of farmers				
Wet season	11	5	10	26	70
Dry season	5	4	1	10	27
Wet/Dry season	0	1	0	1	3
Total	**16**	**10**	**11**	**37**	**100**

x^2 value= 13.606, p.192^{ns} *Contingency coefficient, 0.466*

In irrigated farms or farms that has access to river and spring water, farmers' plant yam during the dry season starting from the month of November to April. During the dry season, the infection usually appears towards the maturity period of the plant or near harvest period. Anthracnose infection during this stage are given less importance by the growers for the reason that the tubers are already matured and ready for harvesting. Unknowingly inoculums from the infected haulms builds-up around the farm especially if proper disposal is not observed and these will be active again during the planting season not only for yam but for other alternate host surrounding the farm.

Harvest period. Maturity of yams or harvest period varies according to varieties which maybe from eight months to one year, which means from December to April if planted at the onset of rainy season. There seems to be a close relationship of harvest season to anthracnose severity at a contingency coefficient of 0.596 though differences are insignificant (Table 16). This could be due to growers' practice of *kapon* where enlarged yam tubers are harvested from six to seven MAP. The marketable yam is carefully detached/ cut-off from the mother plant leaving the smaller yams and the mother plant to continue to grow until full maturity period. The practice of *kapon* is quite income assuring to the grower, but risking the possible infection of the plant brought about by leaving the wound exposed to pathogens and insect pest.

Table 16. Association of yam anthracnose severity to harvest time

HARVEST TIME	SEVERITY				%
	MILD	MODERATE	SEVERE	Total	
	# of farmers				
Wet season	7	1	4	**12**	**33**
Dry season	6	4	6	**16**	**43**
Anytime	3	5	1	**9**	**24**
Total	**16**	**10**	**11**	**37**	**100**

x^2=26.941, p.137^{ns} Contingency coefficient =0 .596

Source of planting materials. The source of planting materials did not differ even with the occurrence of yam anthracnose. Growers (96%) tend to utilize/prefer their own seed stock for the next cropping after the occurrence of yam anthracnose. They rather choose the healthy tuber according to their standards and preserve this for the next cropping season. Yam growers reported that there are limited or no other available quality yam seeds that can be source out from the government or seed producing private institutions. The utilization of their own seed stocks may significantly reflect the degree of severity and year round presence of yam anthracnose. In the grower's perception healthy looking tubers are free from disease and seed degeneration was overlooked. Majority of the yams grown from old seed stock depicts anthracnose infection as presented in Table 17.

Table 17. Source of planting materials before and after occurrence of yam anthracnose and relationship to anthracnose severity

BARANGAY	BEFORE DISEASE INFECTION			AFTER DISEASE INFECTION		
	OWN	BUY	OTHERS	OWN	BUY	OTHERS
Bayabas	4			4		
Kamog	2			2		
Taloy Norte	9			9		
Taloy Sur	6	2		5	2	1
San Pascual	14			13		1
Basil	9			9		
Pallas	5			5		
Total, n=49	**49**	**2**		**47**	**2**	**2**
%	**100**	**4**		**96**	**4**	**4**
ANTHRACNOSE SEVERITY						
Mild				28		1
Moderate				9		1
Severe				11	1	2

multiple response

x^2 value, before and after 14.044, p.171^{ns} 26.774, p.031*

Contingency coefficient 0.472 0.594

Varieties. Anthracnose tolerant and susceptible varieties observed by growers are presented in Table 18. Among the eleven varieties mentioned, *Tuwiran/tungkol* and *Violet* seems to be more tolerant, despite the disease infection observed during the vegetative stage the tuber yield was not affected, while *Deshek/Long* and *Padihot* are the most observed susceptible variety. From the replies however, almost all yam varieties are affected by the yam anthracnose disease.

Table 18. Yam anthracnose tolerant and susceptible varieties as observed by farmers

TOLERANT VARIETIES	# OF RESPONDENTS	SUSCEPTIBLE VARIETIES	# OF RESPONDENTS
Tuwiran/Tungkol	12	*Deshek/Long*	17
Violet	11	*Padihot*	7
White	9	*White*	6
Mindoro	8	*Sampero/Round/ kinampay*	5
Padihot	7	*Mindoro*	1
Deshek/Long	7	*Tuwiran/Tungkol*	1
Ramay-Ramay	5	*Violet*	1
Rapang	3		
Daking	2		
Sampero/round/ kinampay	1		

Fertilizer and pesticide use. Eighty-four percent (84%) of the yam growers in selected barangays of Benguet and Nueva Viscaya usually does not apply synthetic fertilizer and pesticide. If applied, fertilizer are composted weeds and ashes from burned weeds. Sometimes, collected manure from their own animals are added to the compost. Basically, yam plants are dependent on the available soil nutrient. The lack of nutrients for the plants increases its vulnerability to the attack of a pathogen. Calcium is one of the vital nutrients needed by plants to thicken and strengthen its cell wall against an invading pathogen or insect pest. Findings has shown boron (B), manganese (Mn) and calcium (Ca) can significantly inhibit disease invasion in plants by stabilizing and maintaining structural integrity and rigidity of the cell wall (www.crop nutrition.com. Agronomic insights). Ca is an important component of the cell wall structure as calcium polygalacturonates are required in the middle lamella for cell wall stability. Decrease in concentration, there is an increased susceptibility to fungi which preferentially invade the xylem and dissolve the cell walls of the conducting vessels. In addition, plant tissues low in Ca are also much more susceptible to parasitic diseases during storage (Huber 1980). This increases the vulnerability of the plant to infection, and a perfect avenue to the colonizing pathogen thus increasing the incidence and severity of the disease.

Yams with no fertilizer application had the highest percentage of severity recorded as shown in Table 19 where mild to severe infection were noted by 78.4 % of the farmers in the unfertilized yam plants, thus the close association of disease incidence to fertilizer application (contingency coefficient of 0.560). All the growers interviewed are not applying any fungicide to manage the disease. Combined with the occurrence of typhoons passing, this practice greatly contributes to the spread of disease.

Table 19. Fertilization practice and its association to yam anthracnose severity

BARANGAY	FERTILIZER APPLIED			
	NONE	NPK	ORGANIC	ORGANIC/ INORGANIC
	# of farmers			
Bayabas	4	0	0	0
Taloy Norte	9	0	0	0
San Pascual	9	4	1	0
Pallas	5	0	0	0
Basil	9	0	0	0
Taloy Sur	5	0	1	0
Kamog	0	0	0	2
Total , n=49	**41**	**4**	**2**	**2**
%	**84**	**8**	**4**	**4**
SEVERITY				
Mild	11	1	2	2
Moderate	9	1	0	0
Severe	9	2	0	0
Total , n=37	**29**	**4**	**2**	**2**
%	**78.4**	**10.8**	**5.4**	**5.4**

*x^2 value = 22.345, p.009*** *Contingency coefficient =0.560*

Yam anthracnose management mechanisms. The association of yam anthracnose management to anthracnose severity is close at a contingency coefficient of 0.613 though difference in management practices among farmers is not significant (Table 20).

Table 20. Association of yam anthracnose management to anthracnose severity

MANAGEMENT PRACTICED	SEVERITY			
	MILD	MODERATE	SEVERE	TOTAL
	# of farmers			
None/leave the infected yam in the field	13	9	6	**28**
Uproot and throw	1	0	3	**4**
Salvage the healthy tuber and leave the infected	2	0	1	**3**
Change the crop	0	1	0	**1**
Plant tolerant varieties	0	0	1	**1**
TOTAL	**16**	**10**	**11**	**37**

x^2 value = 29.484, p.079^{ns} *Contingency coefficient =0.613*

Although as for the record, farmers that tend to leave the infected crop or plant parts in the field observed more anthracnose infection, followed by those practicing uproot and throw either in compost pit or designated disposal area. Improper disposal of infected plant or plant parts results in the inoculum build-up either in the field or in alternate host then once again the life cycle continues attacking yam in the next cropping season. As a management mechanism, farmers change the crop after infection or plant tolerant varieties. This practice lessens infection and severity because it at least disrupted the life cycle of the fungus. Generally, resistant varieties offer the cheapest and most convenient method of disease and insect management.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The selection of indigenous yam growers in Benguet and Nueva Vizcaya, Philippines was based on the information given by the municipal, provincial offices and farmers association. Most of the respondents are composed of female. Most of them are wives of farmers and some are active village leaders. Most of the area operated for yam production is swidden type (*uma)* ranging from 500 m^2 to 1000m^2. Usually the size of the area is based on the farming capacity of the grower and its family members.

Respondents across locations were all familiar with the disease. It was noted that anthracnose of yam was one of their greatest challenge in production. The severity of the infection was recorded to be during the 4 to 5 months' stage of the plant after planting. This was during the wet season planting and the plant parts that are readily attacked include the leaves, vines and leaf base. In assessing severity of the disease, 57% of the respondents rated yam anthracnose disease as mild, 20% as moderate and 23% as severe.

Sixty-nine percent (70%) of the total growers claimed that their yield significantly decreased due to anthracnose infection and only 30% claimed that the anthracnose has no effect on their yield particularly from barangay Basil, Tublay. The percentage decrease in yield highly differed among growers in the different barangays with 2% of growers in Taloy Sur claiming 100% decreased in their yield. While growers in barangay Bayabas and Taloy Sur reported 51-75 % decrease in yield comprising of 10% of the total growers. Majority of the growers (51%) claimed to have only 26-50% yield decrease and 25% reported 0-25% decrease in yield.

Multiple infection and insect pest damages was also observed to be affecting the yam crops in the locality. Fusarium infection was observed by 12% of farmer-respondents in Taloy Norte. Tuber rotting was also noted by 10% of farmers in Taloy Sur and San Pascual. Only 2% of farmers noted minimal insect pest damages which can be tolerated by the crops until full maturity.

The results imply that the fungus affecting anthracnose disease in yam is endemic in the yam growing areas of Benguet and Nueva Vizcaya especially in the municipalities of Tuba and Sablan. This is a big threat to food security of farmers especially if favorable climatic conditions for the fungus occur. The problems of quality planting materials, limited production and loss of varieties will also continue to threaten yam production and should be given more attention.

The results also suggest that farmers need to adopt improved farm practices like use of clean planting materials, tolerant or resistant varieties, practice farm sanitation and eradication of infected plants and follow recommended crop programming.

The result of this study also contributed in the packaging of the on-going projects, Purple Yam (Dioscorea alata Linn.) Quality Plant Material Production through Aeroponics and Commercialization of Quality Purple Yam (Dioscorea alata) Minisett Planting Materials Towards Enhanced Productivity.

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PART 8

TARO YIELD AS AFFECTED BY DISEASE SEVERITY, INSECT PEST INCIDENCE, AND TARO PRODUCTION PRACTICES IN BULALA, BAYABAS, SABLAN: A CASE STUDY

Ammie D. Ngaotoy and Grace. S. Backian

ABSTRACT

This case study aimed to validate the incidence and severity of major diseases and insect pests affecting taro and its effect on yield as well as document the production practices and pest management interventions of the case farmer. The presence of a standing crop at the time of study and the willingness of the owner-farmer to participate in the research undertaking were the primary factors for the selection of the site. One hundred five sample plants (105) were randomly selected for subsequent disease and insect pest monitoring. Taro late blight and other insect pest were monitored at 12, 14, 16, 18 and 21 weeks after planting. Taro leaf blight severity ranged from 8-25% to 51-75% with the highest average score observed at 18 weeks after planting. On the other hand, the damage caused by armyworm scored from 4.96 to 2.94 which correspond to 5% to ~25% infestation. Similarly, the highest average score of 2.08 or 26-50% damage was recorded at 18 WAP. The data, which was analyzed using multiple linear regression, showed that there is no correlation between severity of taro leaf blight and severity of armyworm infestation on yield. With the foregoing findings, the presence of agricultural extension workers in remote farming communities should be strengthened to provide farmers access to critical services such as soil testing and pest and disease diagnosis. Further, the findings of this study could be used as a baseline to advance studies on seasonal variations in pest occurrence and development of an adaptable pest management strategy for taro growers.

INTRODUCTION

Taro is largely produced in developing countries by smallholder farmers under low input production system (Sing et al., 2012; Taylor & Iosefa, 2013). Nevertheless, it is ranked 9th among food crops (Gananca et al., 2015) and fifth among the most harvested root crop in the world (Adamako et al., 2016). It plays a significant role in the culture and economy of many rural areas (Brown & Daigneault, 2014) such as in Asia, Africa and the Pacific Islands where it is an important staple food (Deo et al., 2009; Gananca et al., 2015; Gebre et al., 2015) as well as a source of revenue to farmers (Azeez & Madukwe, 2010; Chiejina & Ugwuja, 2013; Onyeka, 2014).

Taro production in Asia is dominated by China followed far behind by Japan, the Philippines, Thailand and Taiwan (Moore, 2020). However, taro remains a minor crop in the Philippines compared to other rootcrops like sweetpotato and cassava that are produced in large quantities (Onwueme, 1999). It was further noted that yield is generally low throughout the country which average at less than 5 tons/ha.

In the Cordillera, taro is locally called *gabi*, its vegetative part *pising* and its root portion *abalava* which are shared during regular family meals and also served in special occasions including the feast known as *cañao* (Gonzales et al., 2008). It is not a major cash crop in the region nor the neighboring localities and is commonly planted in small plots along sloping farms, in parts or borders of the backyard, and in rice field or vegetable gardens (Gayao et al., 2019). As it only performs subsistence function, the amount of research and extension services being done on the crop is limited resulting in low technical knowledge base among taro growers and reliance to age-old traditional production methods (FAO, 2003). Similarly, not much attention is given on diseases and insect pests that are major constraints to its production.

Taro leaf blight (TLB) is the most devastating taro disease and is a serious threat to production worldwide (Onyeka, 2014; Nelson et al., 2011). It reduces the number of functional leaves from 6-7 leaves per plant to 3-4 leaves (Jackson, 1999; Cabi, 2106) that lead to a yield loss of up to 30-50% (Misra & Chowdhury, 1987). The disease is caused by *Phytophthora colocasiae* which is mainly a foliar pathogen but also affects the petioles and corms of its hosts (Brooks, 2015). Infected seed tubers serve as primary source of TLB inoculum and the secondary infection is spread by sporangia produced on the leaf surface during the blight phase (Sriram & Misra, 2007). Incidentally, the climatic conditions that favor the growth of taro also aid in the spread of the fungi (Tomas et al., 2020). High humidity and heavy rainfall provide a favorable environment for disease development and rain splash together with wind-blown rain aid in the dispersal of the pathogen (Brooks, 2005; Cabi, 2016). Symptoms start to appear as small, water-soaked spots (Figure 1.b) that increase in size and number as the disease progresses (Figure 1.c). Subsequently, these coalesce and disintegrate forming holes (Figure 1.d) on affected leaves while extensively damaged foliage often hangs on its petiole (Figure 1.e). Leaf senescence for healthy leaves would normally take 40 days from unfurling but only 20 days for TLB-infected leaves (Cabi, 2016). Lesions forming concentric zones and exuding drops of yellow to orange liquid as well as whitish ring consisting of sporangia around the infected leaf area are other symptoms of TLB (Brooks, 2015; Cabi, 2016).

The incidence of insect pests also subject taro production to significant losses. Among the serious pests in the South Pacific region is the taro beetle (TB) (ACIAR, 2008). It has 19 known species of which only 1 belong in the genus *Eucopidocaulus* while the rest are under the genus *Papuana* Moreover, 11 species have been identified as quarantine pests by the Australian government (Biosecurity Australia, 2011). The species under both genera generally feed on the same host and have similar feeding habits. The large adult beetles burrow into the soft trunks, plant bases and corms of a range of plants, including taro, making large holes or cavities up to 2 cm in diameter (McGlashan 2006). Adult female beetles feed aggressively for about a week before leaving the host plant to seek suitable sites for egg laying (TaroPest 2008). These sites include cut down logs, grassland with a silty loam topsoil, river beds and banks with good alluvial soil deposits, logging areas, gardens under fallow, and roadsides where there are host plants present (TaroPest 2008). The eggs are laid 5–15 cm beneath the soil (Onwueme 1999). The larvae hatch from the eggs in 11–16 days, and feed on plant roots and dead organic matter at the base of host plants (Onwueme 1999). The larvae rarely feed on taro corms (Macfarlane 1987). Adult males are most likely to be found in association with the corms, as they tunnel into the corms and remain there, whereas the females seek out sites for laying eggs after mating (SPC 2003).

Consequently, a prior study of the same project documented the prevalence and effect of insect pests and diseases, particularly taro leaf blight (*Phytophthora colocasiae*) and taro beetle (*Papuana* spp.), on household livelihood and food security among taro growers in Benguet and Nueva Vizcaya. The study determined that taro leaf blight (TLB) and taro beetle (TB) has respectively been observed by 100% and 86% of the taro grower-respondents (Gayao et. al.,2019). In terms of the damages caused to the plant, more growers rated taro leaf blight as moderate to severe and taro beetle as mild to moderate. As a follow through, this case study aimed to validate the incidence and severity of major diseases and insect pests affecting taro as well as document the production practices and pest management measures of the case farmer.

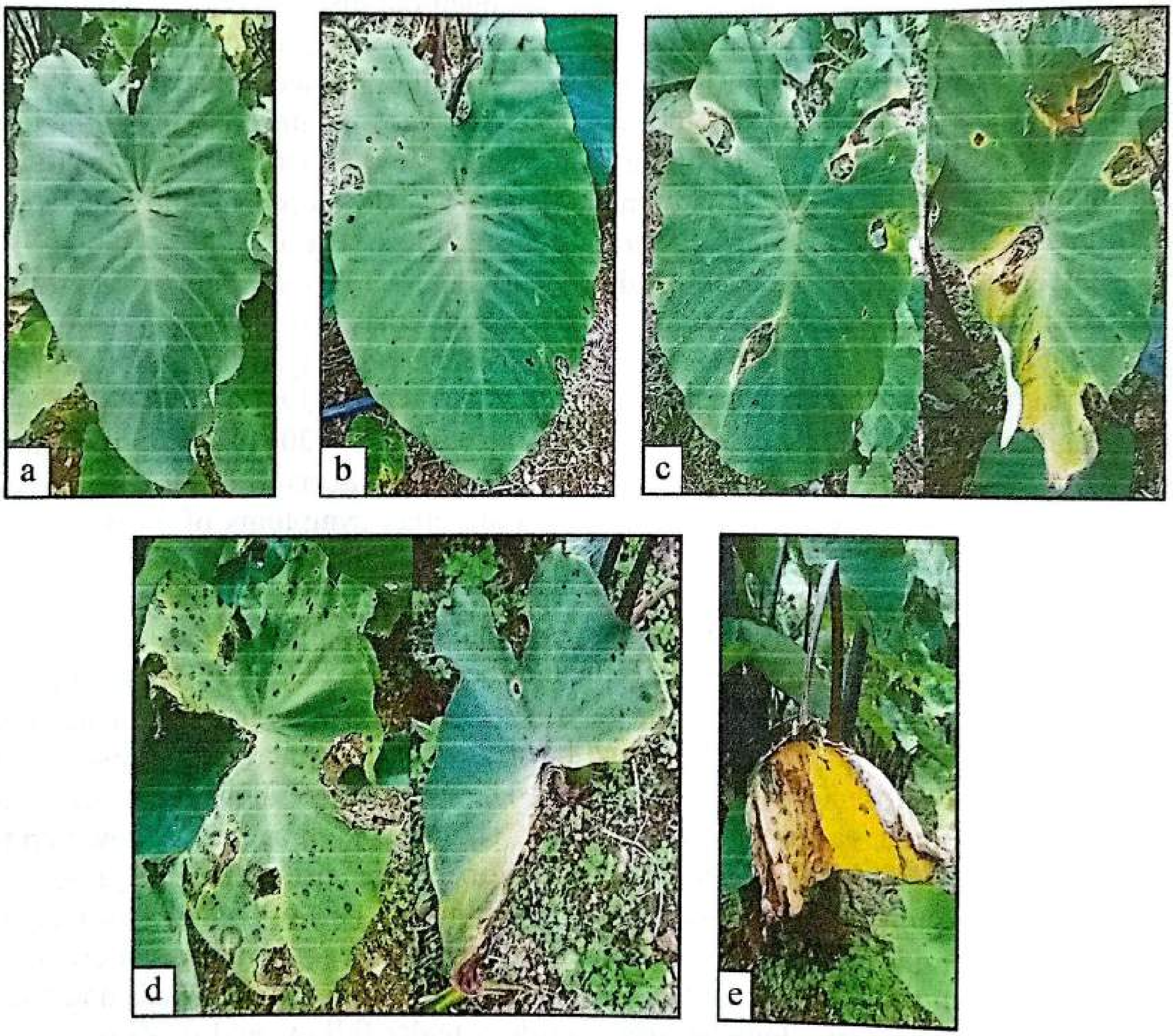


Fig. 1. Symptom development of taro leaf blight. a) Healthy taro leaf; b) Small water-soaked spots; c) Leaf spots increased in size and number; d) Leaf spots coalesce and disintegrate forming holes; and, e) Extensively damaged foliage hanging on its petiole

METHODOLOGY

Description of the Study Area

A taro growing area in barangay Bayabas in the municipality of Sablan in Benguet Province has been identified as case farm representative of taro production under upland condition. The presence of a standing crop at the time of study and the willingness of the owner-farmer to participate in the research undertaking were the primary factors for the selection of the site. The study area is located in *sitio* Bulala and lie geographically at 16.5126 latitude and 120.6192 longitude (Figure 2) with an elevation of 820.8 meters above mean sea level (masl). The temperature in Sablan varies from 12^0C to 25^0C whereby maximum temperatures of 23^0C-25^0C are recorded on the months of February to June and November (meteoblue.com, 2018). On the other hand, the average annual rainfall is 165.5 mm wherein precipitation of more than 100mm is observed from May to October peaking on the month of July (meteoblue.com, 2018). Accordingly, dry season in the area falls on the months of November to April and the rainy season from May to October.

The municipality's temperate climate favors the production of various crops, hence, is predominantly an agricultural community. Rice paddies are found in valleys and mountain sides while the steeper sides of the mountain are being utilized as upland farms for the production of fruits, root crops and tiger grass.

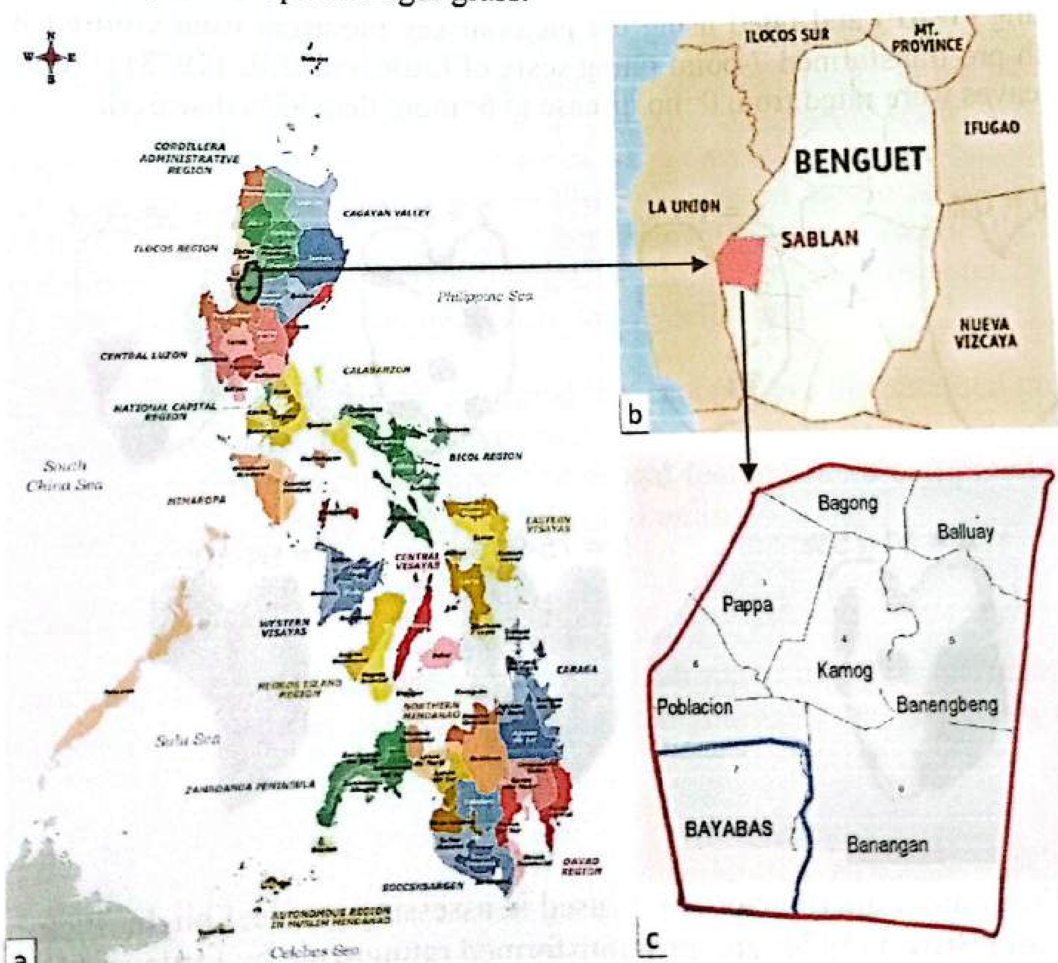


Figure 2. Location map of the study area. a) Map of the Philippines; b) Map of Benguet Province; c) Map of the Municipality of Sablan Sources: a) https://commons.wikimedia.org/; b) https://en.wikipedia.org/; c) https://gadm.org

Evaluation of Taro Leaf Blight (TLB) severity and incidence of insect pests

There was a total of six hundred seventy-two (672) hills of taro on the case farm from which one-hundred five (105) were randomly marked as sample plants for subsequent disease and insect pest observation. Taro stands planted along the border of the field were excluded from being marked as sample plants. Cultural management of the crops and pest management measures were implemented following the farmers' practice.

For periodic monitoring of taro diseases and insect pests, field visits to the study area were undertaken from February 6, 2018 to May 16, 2018. Pest assessment, however, focused on taro leaf blight (*Phytophthora colocasiae*) and or cluster caterpillar (*Spodoptera litura*). Nevertheless, the occurrence of taro beetle and other insect pests were still recorded. Other data collected include plant height (inches), number of leaves, and at harvest, the number and weight of corm and cormels.

Disease Severity

On each block/terrace, disease severity was assessed on thirty-five (35) sample plants. The percentage of plant leaf surface affected by TLB whether by lesions alone or those including lesion-related chlorosis and yellowing was assessed at 12, 14, 16, 18 and 21 weeks after planting (WAP) and rated using the pictorial key modified from Gollifer and Brown (1974) with pre-transformed 7-point rating scale of Little and Hills (1978) (Figure 2). TLB-damaged leaves were rated from 0=no disease to 6=more than 93% diseased.

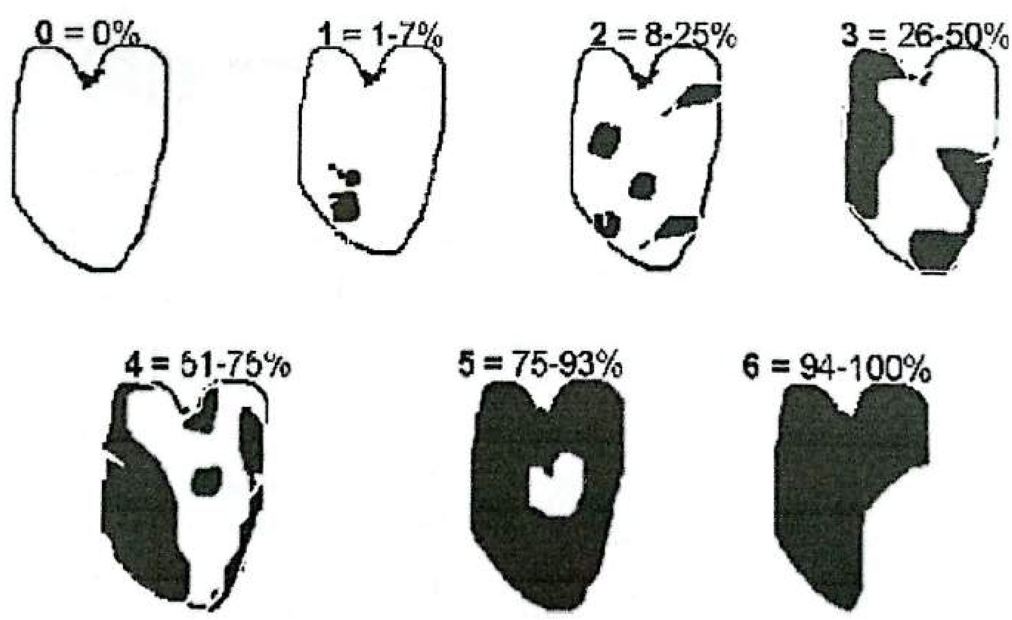


Figure 3. Pre- transformed pictorial key used in assessing taro leaf blight. Pictorial key by Gollifer and Brown (1974) and pre-transformed rating scale by Little and Hills (1978)

Insect Pest Incidence

The damage caused by cluster caterpillar was estimated visually using a five (5) point scale developed by the International Potato Center (CIP) for chrysomelid beetle (Table 1). Assessment was similarly made on the selected sample plants on each terrace.

Table 1. Insect pest rating criteria

Score	Damage
1	More than 50% damage
2	26-50% damage
3	6-25% damage
4	1-5 % damage
5	0 damage

Verification of the TLB-pathogen and Identification of Insect Pests

Collection of samples and identification of the pathogen

During the field visits, infected leaves and petioles exhibiting symptoms of taro leaf blight such as small brown circular speck on the upper surface of the leaf and water-soaked appearance below, large spots with dark brown yellow margins, and presence of yellow exudates, were collected, placed in individual plastic bags and brought to the laboratory for identification. The diseased parts together with the adjacent healthy tissue were cut into smaller pieces of 1-2 centimeters. The cut tissue segments were surface sterilized in 1% sodium hypochlorite for 2 minutes, rinsed in three changes of sterile distilled water, and blotted dry on Whatman paper for 2 minutes. After drying, these were aseptically transferred onto potato dextrose agar medium (PDA; 250 g/L potato, 20 g/L dextrose and 20 g/L agar), incubated at 28^0C for 7 days and examined daily for mycelial growth.

The pathogen was identified by preparing wet mount from the obtained pure cultures and pathogen characters such as hyphae type and shape of sporangia were morphologically examined using the compound microscope. The fungal features were compared to standard established identification guides available in print and online.

Identification of insect pests

The identity of insect pests was verified or determined using printed resources (pest identification guides, extension publications, technical journals) and information available online.

Data Analysis

The data were encoded in Excel software and were transferred for statistical analysis using the Statistical Package for the Social Sciences (SPSS) software. The data were subjected to multiple linear regression analysis to determine the effect of TLB severity and incidence of cluster caterpillar on yield. Level of significance was set at five percent.

RESULTS AND DISUCSSION

Farmers Profile

Mr. Marcelino Garoy (Figure 4a), a senior citizen *Ibaloi* farmer who has been farming for more than fifty (50) years, is the owner of the case farm. He and his family depend mainly on farming for livelihood. His cash crops include cereal grain crops, various lowland fruits and vegetables and root crops. In addition to its commercial purpose, their produce also serves as their main source of food. His extended experience in farming is complemented by attendance to various trainings on crop production and occasional participation as farmer-cooperator in research undertakings such as varietal evaluations of crops. His receptive attitude towards new interventions and technologies merited him to various agriculture-related grants under the government.

He operates three (3) types of farm, namely, swidden farm or *uma* which is situated in the mountain sides, backyard garden and rice field or *talon*. Under these systems, taro is planted in rotation or mixed with other crops. The *uma*, with an estimated area of 5,000 sqm, is planted to fruit trees, various root crops such as greater yam or *ube* and taro, pineapple and ginger, whereas rice, *gabi*, sweetpotato and snap beans are alternately being planted on the 30,000 sqm *talon* while assorted fruits crops and vegetables are grown on the 1,500 sqm backyard garden.

With comparatively wide area, farm tasks are shared by family members. Mr. Garoy's wife, who is also advanced in age, oversees the crops in the backyard which is a short walking distance from their home. On the other hand, Mr. Garoy and one of his sons share chores in managing the rice field and the swidden farm. Labor is sometimes hired especially during harvest. After the rice is harvested, the *talon* is divided between the father and son and work on their respective areas. Mr. Garoy would commonly grow at least 3 types of crops, including taro. These are cultivated separately on different portions of his area. However, as he is alone in tending to his crops, taro is cultivated on a limited area.

Generally, taro is grown as additional source of income. The farmer prefers taro as alternative cash crop as all its parts, the leaves, stalk, and corm, may be sold as well as consumed. On certain months, the price of *ava* or taro corm in the public market may reach as high as Php 120.00 a kilo generating more profit for the farmer. In addition, the crop is used for home consumption and animal feed.

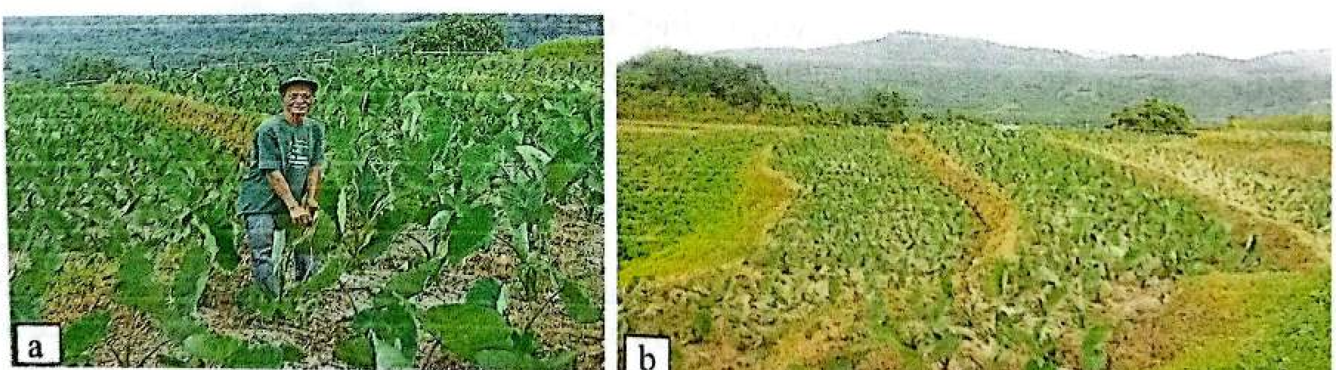


Fig. 4. (a) The farmer, Mr. Marcelino Garoy and (b) study site located in Bulala, Bayabas, Sablan

The Case Farm

Gabi is best adapted to warm and moist environment. During the study, the maximum temperatures recorded in Sablan range from 22^{0}C-25^{0}C (meteoblue.com, 2018). The average annual rainfall, on the other hand, is 165.5 mm wherein precipitation of more than 100mm is observed from May to October peaking on the month of July (meteoblue.com, 2018).

The onset of the rainy season marks the planting of taro and other crops in the swidden farm. However, in the *talon*, rice production is prioritized during the wet season or from May to October. Hence, taro and other crops grown in the rice field are cultivated in the months of November to April or the period between rice harvest and the next rice planting season. Taro production during this period is described as dryland/upland culture which refers to cultivation under non-flooded condition or that is essentially rain-fed. Nevertheless, the farmer endeavors to irrigate his crop whenever water is available usually with the use of sprinklers.

Fig. 5. Taro crop irrigated using a sprinkler

The portion planted to taro in this study occupied three (3) terraces of field covering a total area of 1,500 sq.m. (Figure 4b) which is only 5% of the entire acreage. Other parts of the area are planted to beans, corn and sweetpotato.

Taro Production Practices

Planting Material

The case farmer uses the *pitik* or cormels that were saved from his previous crop as planting material. The cormels come from the axillary buds present in the corm. This planting material, however, are susceptible to attack by disease-causing organisms (BPI-DA, Undated). Being aware that the use of diseased planting materials is a means to transmit diseases, the farmer practices positive selection or obtain cormels only from healthy-looking and vigorous taro stands. Plants showing symptoms of disease infection are avoided as source of plant materials. The cormels, weighing around 20-25 grams each, are air-dried and dusted thinly with insecticide (Sevin brand). These are further coated with wood ash which, according to the farmer, prevent fungal infection. The planting materials are then placed in woven baskets lined with polypropylene sack or wooden containers and stored in a well-aerated location. The long storage period allows the cormels to sprout and ready for planting in the field. Prior to planting, the planting materials are again inspected to ensure that they are free from diseases. Cormels showing symptoms of infection are disposed off properly.

Fig. 6. *Pitik* or cormels are used as planting material

When disease infection is high during the production period, all harvest are sold or consumed. Hence, planting materials for the next cropping period would be sourced from other farmers. These are usually acquired from taro growers in Libtong, Burgos in the province of La Union. The small cormels, locally called as *bolintik* or marble, measure about 0.5 to 1 inch in diameter and are priced at Php 1.00 apiece.

There are two (2) common varieties cultivated by the farmer. The *Itchina* or Chinese variety is primarily preferred by the farmer, however, when planting material of the said type is not available, *Mindanao* variety is used. The farmer prefer these varieties for their tolerance to taro leaf blight. The leaves of the *Itchina* are green, droopy and broad with leaf vein that is whitish green with light purple coloration. It produces 2-5 rhizomes with corms that has white periderm and purplish fibers. *Mindanao*, on the other hand, grows taller than *Itchina* and is distinguished by its greyed-green petioles and green leaves with yellow-green leaf vein. The corm has yellow flesh and brownish skin with 2-3 rhizomes that matures later than *Itchina*.

Agronomic Practices

Before planting, the field is prepared by thoroughly plowing and harrowing the land with the use of a carabao and plow or a tractor to pulverize the soil as well as remove weeds. A well-prepared soil influence high yield (Gonzales et al., 2008). Taro is cultivated as sole crop and are planted with spacing at 90 cm between rows and 70 cm between plants at about 10 cm deep. The recommended plant depth under flat culture and rain-fed irrigation is 8-10 cm during the dry months (BPI-DA, Undated). This is followed by the farmer to prevent new corms from developing above the soil surface and exposing the corms to damage by insect pests (Gonzales et al., 2008). After planting, dried rice hays are placed around the taro crops as mulch which contributes to soil water management, weed control, and fertilization (Onwueme, 1999; BPI-DA, Undated).

Unlike in flooded taro where weed is minimal, weed control is critical particularly during the first 8-10 weeks after planting or until plant canopy has closed (Onwueme, 1999; BPI-DA, Undated). Hence, mulching is important as it provides some degree of weed control (Gonzales et al., 2008). Persistent weeds are controlled manually by hand or use of plow.

In fertilizer application, it is recommended that a soil test be undertaken to determine the nutrient requirement of the soil. However, the farmer is not able to avail of this service. Nevertheless he uses fertilizer to his crops particularly ammonium phosphate (16-20-0) which is applied at 1 tablespoon (tbsp) per plant at 15-days interval. The farmer explained that this is the only type of fertilizer used as the crop would utilize the residual fertilizer applied during rice production. Bilkis et al. (2018) noted that inputs from the preceding crops such as fertilizers and organic matters influence the responses of succeeding crops. Their study showed that the application of various combinations of manure, trichocompost, vermicompost and chemical fertilizers on potato-mung bean-rice cropping pattern can increase N, P, K and S content, uptake by and significant positive residual effect on yield parameters of mung bean.

Aside from soil testing, the farmer has also yet to avail of plant disease diagnosis services. To identify the pests affecting his crop, the farmer relies on disease symptoms and presence of insect pest and the damage caused which he had observed over his long years of farming.

As management interventions for taro pests, cultural and chemical control are both employed. Cultural management practices such as crop rotation, positive selection of planting materials and proper disposal of infected plants and/or plant parts are implemented. Lebot (2009) identified cultural control as an effective approach to restrict the damage made by taro beetle, an important pest of taro. Under chemical management, 50g (1 sachet) of fungicide (Ridomil Gold, active ingredients: Metalaxyl-M (40g/Kg) and Mancozeb (640g/Kg) is dissolved in sixteen (16) liters of water and sprayed to the plants as disease management measure primarily for taro leaf blight. For insect pests, carbaryl insecticide (Sevin WP) is usually used. This broad-spectrum carbamate insecticide contains 850 grams/kg carbaryl and controls sucking and chewing insects affecting various crops through ingestion or physical contact with the powder. Brown and Daigneault (2014) found in their cost-benefit analysis that chemical controls are both effective (as measured by the net present value) and efficient (as measured by the ratio of benefits to costs) for managing taro beetle (*Papuana uninodis*) in Fiji.

Harvesting and Postharvest Handling

The time of harvest depends on the variety used and the prevailing conditions during the production (Gonzales et al., 2008). The *Itchina* variety normally reach maturity at 5-7 months under dryland production. The *Mindanao* cultivar takes longer to time mature. The farmer noted that a decline in the height of plants and general yellowing of the leaves are indications that the crops are ready for harvest. The high price of taro in the market is another factor considered by the farmer in harvesting.

Harvesting is mostly done using hand tools. *Suwal* (Figure 6a) and trowel are used to loosen the soil around the plant and the corm is pulled up by holding the base of the petiole. Woven baskets (Figure 6b) are used to carry the harvested taro from the field to the cleaning and sorting area.

Postharvest handling simply involves cleaning, sorting, packing and shipping. The corms are cut from the petioles and are sold separately. The petiole and leaves are sold together either as fresh produce (Figure 6c) or in pre-sliced/ready-to-cook packages. Damaged corms are still marketable after cutting off the damaged parts and added to the pre-sliced packs. For non-infested corms, these are packed in polypropylene sacks before being brought to the market.

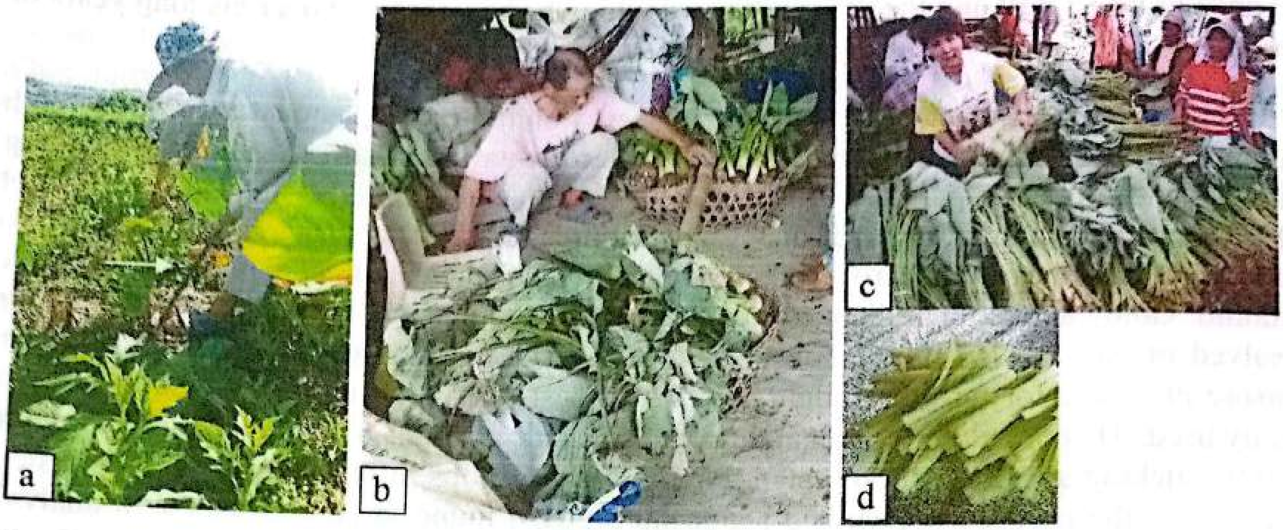
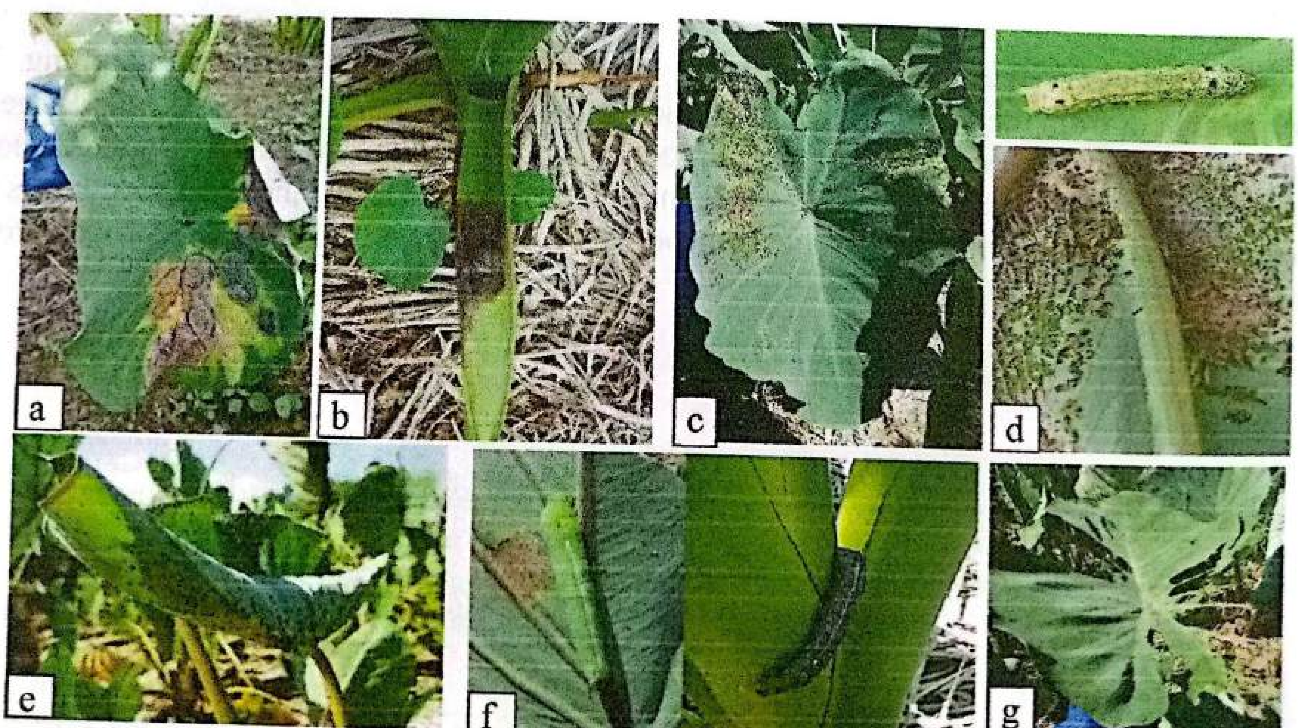


Fig. 6. (a) Harvesting using the *suwal*; (b) woven baskets are used to carry the harvested taro from the field; (c) fresh taro petiole and leaves being sold in the market (Source: http://www.marketmanila.com/archives/gabi-leaves-in-albay-cebu-and-palawan); (d) sliced taro petioles

Plant Disease Severity and Insect Pest Incidence

The diseases observed affecting taro crop are taro leaf blight, corm soft rot and sclerotium rot. The latter two were observed at harvest. On the other hand, the insect pests observed in the field were cluster caterpillar, hornworm, aphids, and taro beetle (Figure 5). During the study, taro leaf blight and cluster caterpillar were identified as the most common pests observed in his field. In a discussion with the farmer, he considers the taro leaf blight to be more destructive than the cluster caterpillar in terms of damage citing the likelihood of widespread infection, rapid destruction of and reduction in number of functional leaves, and, consequent decline in yield or even plant death.



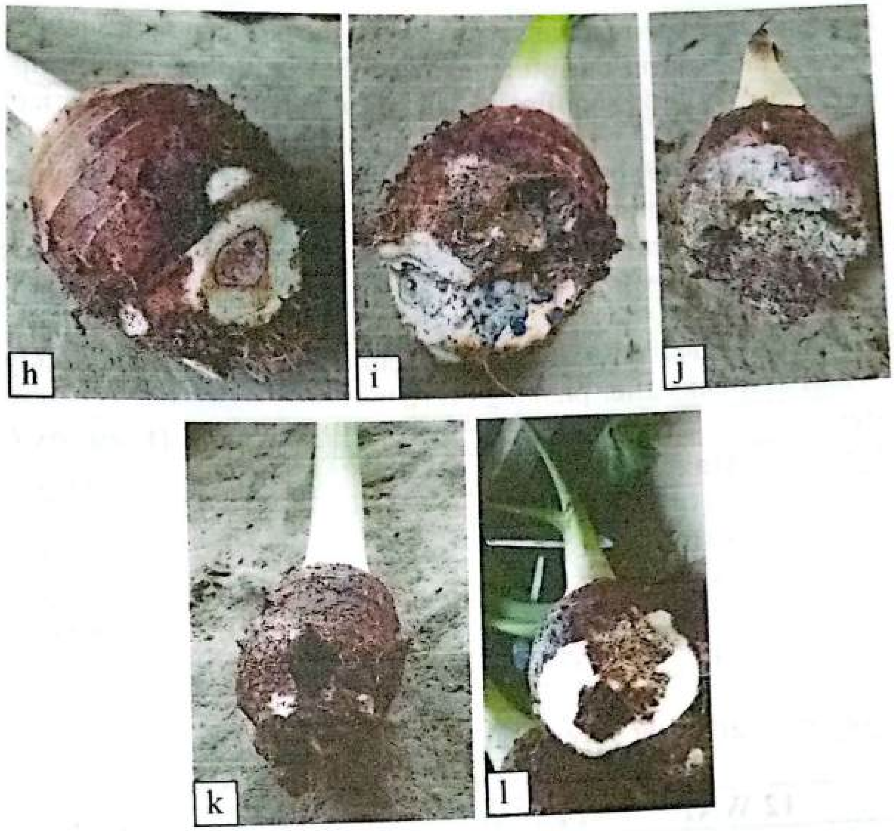


Fig. 7. (a) Purplish brown to brown leaf lesions forming concentric zones that area starting to coalesce caused by taro leaf blight; (b) TLB symptom on petiole; (c) feeding damage caused by cluster caterpillar; (d) larvae of the cluster caterpillar (top) and close-up photo of the damage caused by cluster caterpillar; (e) taro leaf infested with aphids; (f) hornworm larva, becomes dark brown (right) when mature and moves to the soil, form a cocoon in the leaf litter or just below the soil and pupate; (g) taro leaf damaged by hornworm; (h&i) corm soft rot suspected to be caused by *Pythium* sp.; (i) corm rot suspected to be caused by *Sclerotium rolfsii;* (k&l) damage to a taro corm by taro beetle;

In the disease rating, the score recorded for taro leaf blight severity ranged from 1.96 (~8-25%) to 4.14 (51-75%) (Table 3). The highest average was observed at 18 weeks after planting with a score of 3.58 which indicate 26-50% infection. This may be attributed to the high humidity shown in Table 2 where the highest percentage was noted at 18 WAP. High humidity provide a favorable condition for occurrence of *P. colocasiae* (CABI, 2019).

On the other hand, the damage caused by cluster caterpillar scored from 4.96 to 2.94 which correspond to 5% to ~25% infestation. In line with the rating criteria used, a lower value denotes higher damage. Hence, the highest average score, which was observed at 18 WAP, was 2.08 or equivalent to 26-50% damage.

Using multiple linear regression analysis, the data, however, showed that leaf blight and clustercaterpillar severity has no relationship with yield (ANOVA Table). This finding contradicts typical plant disease evaluations where disease severity and yield are directly related (Fry, 1982). However, Cox (1986) stressed that healthier and more resistant plants tend to maintain heavily diseased leaves while susceptible plants lose infected leaves, thus, retain only young leaves with fewer infections may explain the production of yield even at high pest severity. However, the data in this study showed that only the relationship between plant height at 14 WAP and yield is significant. This means that 6% of the variability of yield is explained by plant height at 14 weeks and that for every 1 unit increase in plant height, there is 0.098 increase in yield. The absence of association between disease and insect pest severity and yield may potentially be attributed to the production practices of the case farmer. In addition, it may either be because of the small reduction in yield or the moderate (26-50%) TLB and cluster caterpillar severity, or both.

Table 2. Agro-Meteorological data showing the temperature (^{0}F) and humidity (%) at 12, 14, 16, 18 and 21 weeks after planting (WAP)

Weeks After Planting (WAP)	**Temperature (^{0}F)**			**Humidity (%)**		
	Max	**Ave.**	**Min.**	**Max**	**Ave.**	**Min.**
12	68.0	59.9	55.0	91.0	77.1	57.0
14	80.0	68.1	59.0	98.0	76.0	40.0
16	78.0	68.8	62.0	86.0	72.0	31.0
18	72.0	63.1	57.0	98.0	88.9	82.0
21	74.0	67.4	63.0	96.0	81.4	68.0

Table 3. Score of taro leaf blight severity at 12, 14, 16, 18 and 21 WAP

Block	**Taro Leaf Blight Severity**				
	12 WAP	**14 WAP**	**16 WAP**	**18 WAP**	**21 WAP**
I	2.80	3.50	2.63	3.47	1.96
II	3.58	3.84	2.57	3.14	3.14
III	3.51	3.11	3.35	4.14	4.01
Average	3.30	3.48	2.85	3.58	3.04

Table 4. Score of armyworm severity at 12, 14, 16, 18 and 21 weeks after planting (WAP)

Block	**Armyworm Severity**				
	12 WAP	**14 WAP**	**16 WAP**	**18 WAP**	**21 WAP**
I	-	-	4.60	-	-
II	3.67	3.63	3.26	3.0	4.0
III	3.40	3.55	2.94	3.23	4.42
Average	2.36	2.39	3.6	2.08	2.81

Table 5. Plant height (inches) and number of leaves at 12, 14, 16, 18 and 21 weeks after planting (WAP)

Block	Plant Height (inches)					Number of Leaves				
	12 WAP	14 WAP	16 WAP	18 WAP	21 WAP	12 WAP	14 WAP	16 WAP	18 WAP	21 WAP
I	21.99	24.61	27.89	31.59	27.38	4.43	4.24	4.64	4.41	4.26
II	33.16	36.84	36.93	41.24	37.84	4.56	4.41	4.37	4.28	3.81
III	26.80	29.03	30.43	31.60	33.17	5.29	4.23	4.31	4.06	3.89
Average	27.32	30.16	31.75	34.81	32.80	4.76	4.29	4.44	4.25	3.99

Table 6. Number and weight (g) of corms and cormels at harvest

Block	Number (pcs)			Weight (g)		
	Corms	Cormels	Total	Corms	Cormels	Total
I	34	146	180	11,399	7,061	18,460
II	33	134	167	14,275	14,115	28,390
III	35	144	179	10,494	10,419	20,913
Average	34	141.33	175.33	12,056	10,531.67	22,587.67

ANOVA

Model	p-value	Sig
Plant height (12 WAP)	0.264	Not significant
Plant height (14 WAP)	0.039	Not significant
Plant height (16 WAP)	0.958	Significant
Plant height (18 WAP)	0.541	Not significant
Plant height (21 WAP)	0.071	Not significant
No. leaves (12 WAP)	0.533	Not significant
No. leaves (14 WAP)	0.609	Not significant
No. leaves (16 WAP)	0.239	Not significant
No. leaves (18 WAP)	0.486	Not significant
No. leaves (21 WAP)	0.122	Not significant
TLB severity (12 WAP)	0.852	Not significant
TLB severity (14 WAP)	0.964	Not significant
TLB severity (16 WAP)	0.472	Not significant
TLB severity (18 WAP)	0.861	Not significant

Model	p-value	Sig
TLB severity (21 WAP)	0.525	Not significant
Cluster caterpillar severity (12 WAP)	0.259	Not significant
Cluster caterpillar severity (14 WAP)	0.824	Not significant
Cluster caterpillar severity (16 WAP)	0.275	Not significant
Cluster caterpillar severity (18 WAP)	0.646	Not significant
Cluster caterpillar severity (21 WAP)	0.581	Not significant
Hornworm incidence (14 WAP)	0.928	Not significant
Hornworm incidence (16 WAP)	0.509	Not significant
Hornworm incidence (18 WAP)	0.359	Not significant
Hornworm incidence (21WAP)	0.071	Not significant
Aphid severity (16 WAP)	0.857	Not significant
Aphid severity (18 WAP)	0.359	Not significant
Aphid severity (21 WAP)	0.071	Not significant
Taro beetle damage severity at harvest	0.392	Not significant
Corm soft rot damage severity at harvest	0.973	Not significant
Sclerotium rot damage severity at harvest	0.292	Not significant

Dependent variable: Yield (number of corms)
**LS: p=0.05;*
Incidence of hornworm at 12 weeks and aphid severity at 12 and 14 weeks have a constant value of 0, thus, was removed from the analysis

Model Summary

Predictor	r-square
Plant height (14)	0.06

**6% of the variability of yield is explained by plant height at 14 weeks*

Coefficients

Model	Coefficients
Constant	2.250
Plant height	0.098

**For every 1 unit increase in plant height, there is 0.098 unit increase in yield.*

SUMMARY, CONCLUSION AND RECOMMENDATION/S

Taro production in Bulala, Bayabas, Sablan follows after rice harvest which usually cover the months of November to May. It is cultivated for commercial purpose as well as for home consumption and as animal feed. Farming activities are shared among family members. Consequently, the area planted to *gabi* is determined by available labor. The farming practice in the study site is characterized as upland/dryland culture wherein irrigation is essentially rain-fed. Moreover, conventional farming practices, such as application of chemical fertilizers and pesticides, are observed.

The findings of the study revealed moderate severity of taro leaf blight. The rating score which is rounded off to 3 indicate that the disease caused 26-50% damage to the crop. To manage this, the case farmer utilize cultural and chemical management measures which include crop rotation, use of taro varieties with resistance to the disease, obtaining planting materials from healthy-looking taro stands and clean source, following the recommended planting distance, proper disposal of infected plants, and, application of fungicide.

The study also documented the insect pests affecting taro from the insect orders namely Spodoptera (cluster caterpillar), Lepidoptera (hornworm), Hemiptera (aphids), Orthoptera (cricket) and Coleoptera (taro beetle and grubs). In terms of infestation/damage caused, most are characterized as low (25% or lesser) to negligible (less than 5%). The most damage was observed to be caused by armyworm which was assessed at 8-25%.

Analysis of data further showed that there is no correlation between taro leaf blight and armyworm severity and yield.

Severity assessment of the target pests were less than 50%. However, the likelihood of said pests to become serious threats is high. Accordingly, regular pest monitoring activities should be sustained. Moreover, the presence of agricultural extension workers in remote farming communities should likewise be strengthened to provide farmers access to critical services such as soil testing and pest and disease diagnosis. Lastly, the findings of this study could be used as a baseline for further studies on seasonal variations in pest occurrence and development of an adaptable pest management strategy for taro growers.

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PART 9

SWEETPOTATO FUSARIUM WILT AND OTHER INSECT PESTS AND DISEASES FROM PLANTING TO HARVEST IN CONIG, CENTRAL KAPANGAN, BENGUET: A CASE STUDY

Grace S. Backian, Jophr L. Galian and Ammie. D. Ngaotoy

ABSTRACT

This case study was done to validate field observation on the incidence and severity of sweetpotato fusarium wilt and other insect pests and diseases and its effect on yield and farm income. Selection of the case study site was done based on a baseline survey on the prevalence of sweetpotato fusarium wilt and the willingness of the farmer as case respondent. Sweetpotato production was affected not only by biotic factors but also abiotic factors like climate, varietal reaction to insecst pest to attain optimum yield. Incidence of sweetpotato fusarium wilt was recorded at 3% and was observed on the sixth and seventh month after planting. Insects observed during the cropping season were classified as foliage defoliators with a damage of 51-100% at seven months maturity. High rainfall and humid conditions affected the canopy cover of the sweetpotato thereby affecting storage root formation. Diseases like sweetpotato fusarium wilt can satisfactorily be controlled with resistance and use and production of clean planting materials can be set as a standard for sweetpotato farmers towards sustainable sweetpotato production.

INTRODUCTION

Sweetpotato (*Ipomoea batatas* L.) is a tropical tuber species, primarily grown in the developing world by smallholders. It ranks fourth in terms of world most important food crops, after rice, wheat and corn (Babatunde et al., 2007; Nwaru, 2011). Its primary use is as a food crop; some of the surplus is sold along with other produce from home gardens (Horton et al., 1983). The crop is a versatile component of the agricultural system; it has the capacity to produce a significant quantity of carbohydrates, and the protein and vitamin content enhances its value.

In the Cordillera Region of the Philippines, 250 kilometers north of Manila, sweetpotato is an important crop especially in areas where development is low. Most of the sweetpotato grown in the Cordillera uplands are for home consumption basically as a staple or supplement to rice. The rise of commercial farming with use of technology packages biased toward cash crop production has marginalized the crop. However, sweetpotato commercial production is evidenced in some areas of Cordillera but not widely observed.

In Benguet Province, sweetpotato is grown by =/-3,385 households where municipality of Kapangan accounts for the highest number of households growing sweetpotato. Also, the municipality accounts for the highest number of has planted to sweetpotato in the province.

Farming is one of the people's livelihood and the major crops planted are bell pepper, beans, chayote, tomato cucumber, sweetpotato, taro yam and tiger grass (Gayao, et al. 2019). These crops are either planted in the swidden farm, rice field, garden or at the backyard garden. Cultivation of sweetpotato is done mostly in the *uma* or swidden field. However, expansion of *uma* or swidden field has been restricted nowadays because of environmental concerns.

Sweetpotato production in Kapangan, is not only limited to household consumption but has also been expanded for commercial purposes, planted after rice though swidden farms are still the most utilized farm scape for sweetpotato. Production, however declined in recent years because of the incidence of sweetpotato fusarium wilt (SPFW) which according to farmers has started in 2012. Based on assessment of the local government unit-municipal agriculture office (LGU-MAO) of Kapangan, incidence of sweetpotato fusarium wilt ranged from 55-75% and resulted to loss of varieties, decrease in yield and loss or decrease in livelihood or farm income (Gayao, et al., 2019).

Fusarium wilt caused by *Fusarium oxysporum* is one of the most damaging soil-borne diseases of economically important crops like tomato, beans and banana. The pathogen can survive in the soil and in debris for several years as chlamydospores, the survival structure of fusarium wilt. There are other sweetpotato diseases that are of economic importance like sweetpotato scab, and its occurrence is dependent on climatic factors and varietal resistance.

Insect pests likewise attack sweetpotato at different growth stages. Most of these pests are plant defoliators. Insect pests classified as tuber feeders affect the quality of produce thereby affecting consumption. Sweetpotato weevil or *balitungeg* (*Cyclas formicarius*) comes next to SPFW according to 73% sweetpotato farmers in Benguet and Nueva Vizcaya. Sweetpotato weevil, which causes the terpene odor and bitter taste of damaged sweetpotato storage roots, is a stem and tuber feeder making the storage roots unfit for human consumption (Vasquez, 1990). The foregoing problems have affected sweetpotato production in Kapangan and other neighboring municipalities, hence the case study was done with the following objectives:

1. Monitor and assess the incidence and severity of sweetpotato fusarium wilt and other insect pests from planting to harvest
2. Determine incidence and severity of other pests affecting the sweetpotato crop and its effect on yield
3. Determine the effect of sweetpotato insect pests on yield and farm income

METHODOLOGY

Site selection and description

The case study was done in Sitio Conig, Central Kapangan barangay with an elevation of 1,044 masl. Selection was primarily based on the willingness of the farmer. Sweetpotato variety *Geslayan* was used in this study and was planted after rice, in a 200m^2 flat area. The area is isolated and there are no other sweetpotato crop near the case study site. Planting was done during the dry season (February) where planting materials were taken from a previous field located in another area that is owned by the farmer.

The area was divided into 3 blocks and sample plants were tagged at random.

Data collection

The incidence of SPFW and other diseases was monitored 4 months after planting (MAP) and every 2 weeks thereafter until harvest. Incidence of other insect pests and diseases was recorded using a scale of 1-5. Assessment was based on symptoms exhibited by the plant and validated in the laboratory.

The following rating were used to record fusarium wilt incidence and insect damage:

Sweetpotato Fusarium Wilt Damage

Rating scale	Description
0	Healthy plant
1	Length of tan vascular system was abt. 5 cm.
2	Some older leaves turned yellow and the length of the tan vascular system was about 1/3 of the total plant length
3	Older leaves became yellow and the tan vascular system was about 2/3 of the total plant length
4	All leaves became yellow and the tan vascular system extended to plant tip
5	Dead plant

Insect Damage (mirid bug)

Rating Scale	Description
1	No damage
2	Light (1-10%)
3	Moderate (11-25%)
4	Heavy (26-50%)
5	Severe (51-100%)

Laboratory analysis

Soil and diseased samples of sweetpotato crop were collected from selected farmer's case study site, stored in separate plastic bags and brought to the NPRCRTC Plant Health Clinic for isolation and identification.

Statistical analysis:

Data were encoded in EXCEL and analyzed using the SPSS software. Hotelling's T Square was the analysis used to test the significance of the data at 5% Level of Significance.

RESULTS AND DISCUSSIONS

Respondent's profile:

Mr. Nestor Bayating is 63 years old sweetpotato farmer from Conig, Kapangan Central, Benguet. His family has multiple sources of income which include crop sales, business (trading) and from gifts given by children. Food supply (rice) comes mainly from own produce in rainfed areas (*talon*).

Farming Practices on Sweetpotato:

Sweetpotato is planted in monocrop as main rotation in ricefield (*talon*). Fertilizer application is one of his practices in sweetpotato production. Fertilizer application is done (NPK/Complete) 45 days after planting but no to application of pesticides.

Climatic conditions during the cropping period

Different sweetpotato varieties have different responses to climatic conditions. Some varieties have high storage root yield, others have low root yield but high top yield (Chunsheng and Meiying, 1992). Sweetpotato requires sun and a warm soil. Sweetpotatoes need 3 to 4 months of warm temperatures for optimum yield so the key is plant them early for the crop to mature properly. Chowdhury (1994) and Ravi and Suravanan (2012) claimed further that tuber bulking has a positive correlation with rainfall and relative humidity.

Fig. 1. Case study on sweetpotato three months after planting (3MAP)

Table 1. Climatic conditions during the cropping period (La Trinidad, Benguet)

MONTH (2018)	TEMPERATURE (°C)	RAINFALL (mm)	HUMIDITY (%)
February	13 - 23	0.1	90
March	13 - 24	0.2	89
April	15 - 23	4.8	90
May	17 - 34	18.0	89
June	21 - 23	23.9	92
July	17 - 23	28.2	93
August	16 - 23	17.2	91
Mean	16-28	13	91

Source: BSU-DOST Agromet Station

INCIDENCE OF INSECT PESTS AND DISEASES

Sweetpotato Fusarium Wilt. The incidence of SPFW was monitored 4 months after planting (MAP). Infection of sweetpotato fusarium wilt was evident at 6 and 7 months after planting with a rating of 2 which means that some older leaves turned yellow and the length of the tan vascular system was about 1/3 of the total plant length. Incidence of sweetpotato fusarium wilt was recorded at 3%.

Previous studies done by Gayao et al., (2019) documented that SPFW is present whether wet or dry months. Factors like variety, source of planting materials may have attributed to disease tolerance. Variety *Geslayan* was among the varieties identified by the sweetpotato farmers that has tolerance to sweetpotato fusarium wilt. In a field trial conducted in Nueva Vizcaya (2016), variety *Geslayan* exhibited tolerance to sweetpotato fusarium wilt.

Table 2. Average severity rating of sweetpotato fusarium wilt

Block	4MAP	5MAP	6MAP	7MAP
1	0	0	0	0
2	0	0	0	2
3	0	0	2	2

p-value 0.25^{ns}

Sweetpotato Root Rot. The sweetpotato root rot was observed during harvest. No symptoms were observed in the haulm during the cropping period to show infection. Climatic data showed that heavy rainfall (16-24mm, Table 1), in the last two months before harvest as well as delayed harvest may have attributed to the rotting incidence of the storage roots.

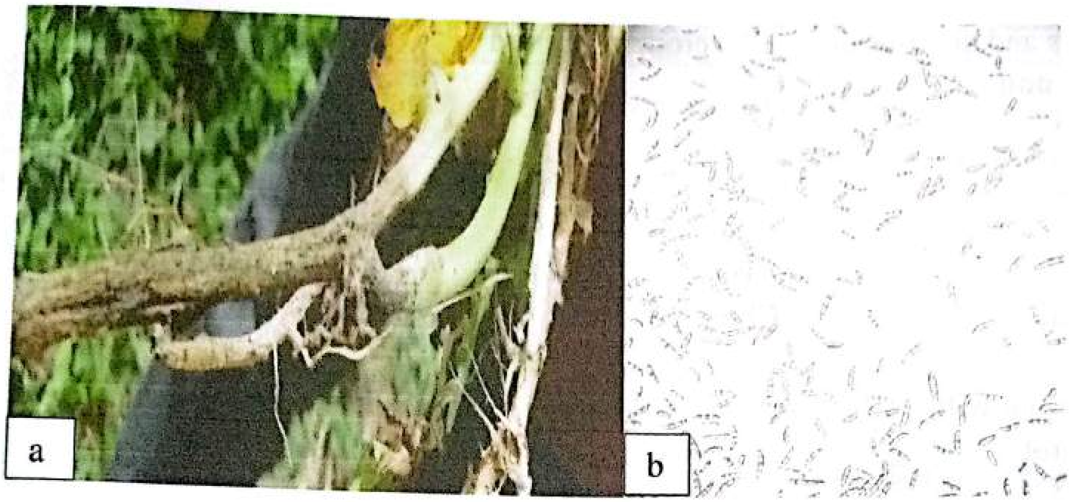

Fig. 2 (a) Symptom of fusarium wilt in sweetpotato vines and (b) microscopic appearance of fungal spores of fusarium isolated from infested soils planted to sweetpotato

INSECTS

Insect pests when compounded to other diseases cause severe infection. Insects observed during the cropping season in this case study were classified as foliage defoliators.

These were the mirid bug and tortoise beetle. Adult and nymph of the mirid bug feed on the young shoots of sweetpotato and the damage is characterized by water-soaked lesions, blackening or malformation of the feeding site and finally drying up of the shoots (Fig. 2a). These insects are abundant during the rainy season (Vasquez, 1990).

The green tortoise beetle was also noted during the cropping period. The green tortoise is one of the most common species. With the short incubation of this insect (4-7 days), there incidence can be damaging. Though, in this case study, rating of 5 which is equivalent to 51-100% damage was noted at seven months maturity. For the farmers, damage is not economically important because root formation is not affected.

Foliage defoliators have lesser damage than the stem and tuber feeders although can threaten sweetpotato production during pest outbreaks (Vasquez, 1990).

A minimal percentage (1.6%) of rat infestation was observed during harvest. Rats are considered pests because they affect the yield.

Table 3. Insect pests and diseases during the cropping period

Insect Pests and Diseases	Scientific name/Family	Plant parts affected
Insects		
Mirid bug	*Helopeltis sp.*	Leaves
Grasshopper	*Phaneroptera furcifera*	Leaves
Green tortoise beetle	Chryomelidae	Leaves
Diseases		
Sweetpotato fusarium wilt	*Fusarium oxysporum*	Stems, storage roots
Sweetpotato root rot	*Erwinia spp.*	Storage roots
Others		
Rats		Storage roots

At 5 MAP, all samples had a rating of 2 which is equivalent to 1-10% infection. Severe damage with a rating of 5 (51-100%) was noted at seven months after planting. Severity of insect damage caused by the mirid bug is significantly different at 5, 6 and 7 months after planting (Table 4).

Table 4. Mean rating scale of insect damage during the cropping period (mirid bud)

Block	5MAP	6MAP	7MAP
1	2	3	4
2	2	4	5
3	2	4	5

*p-value 0.0011***

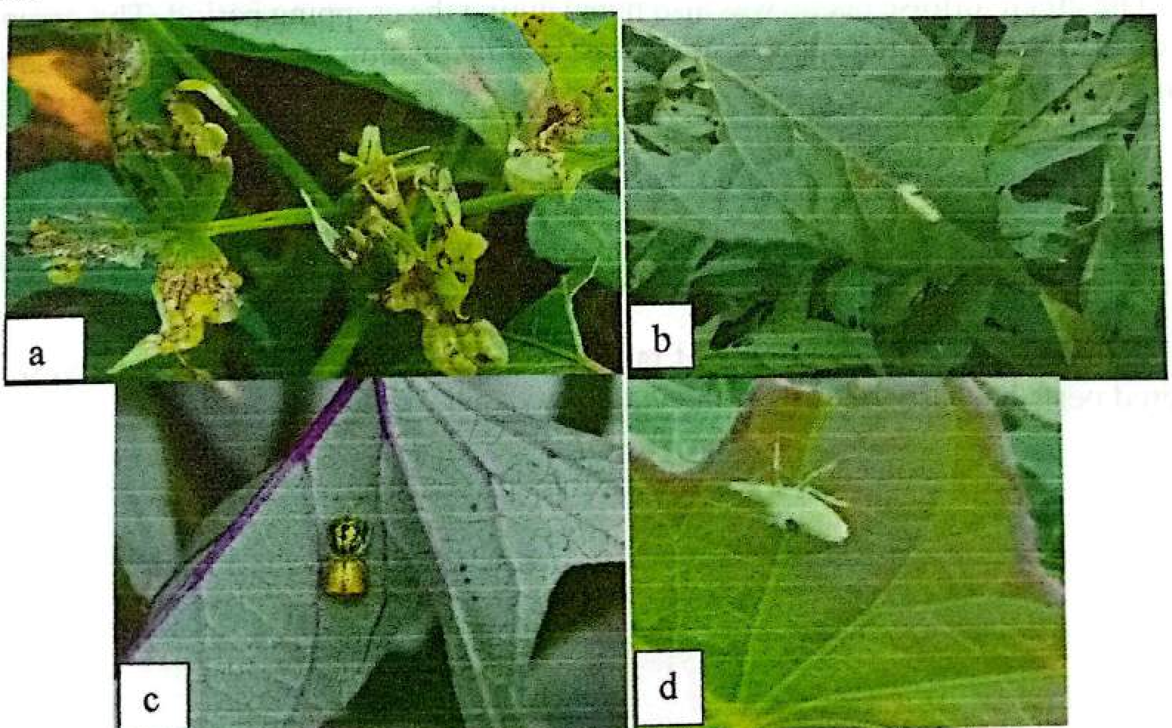

Fig. 2. (a) Sweetpotato shoots infected by mirid bug; (b) Tortoise beetle; (c) leaf damage caused by tortoise beetle; and (d) grasshopper observed during the cropping season

Root Yield

The average root yield was 0.25kg/hill. This means that if the previous harvest of the farmer is 2 kg/hill, there is 88% decrease in yield. This is more than the percent reduction in yield as assessed by the office of the municipal agriculture office (LGU-Kapangan) which ranged from 55-75% loss. Based on observation, the reduction was attributed to the canopy cover. The prevailing average temperature was 15.88 – 24.47°C and average relative humidity was 90.57% during the cropping period (La Trinidad condition). High temperature and humid conditions are very favorable for canopy growth. Widaryanto and Saitama, 2017 claimed further that sweetpotato grown during the wet season results in a longer age and lower root production because sweetpotato plants will have a long vegetative phase especially on leaves.

In La Trinidad condition, the variety *Geslayan* starts to form roots at five (5) months after planting and is ready for harvest at six (6) months after planting. Other long maturing varieties mature at 4 months. Before harvest at seven months after planting, the farmer cooperator harvested 30 bundles which he mentioned was given as fodder to farm animals (carabao).

Loss or decrease in farm income

The household of Mr. Bayating has multiple sources of farm income which include crop sales, business (trading) and from gifts given by children. At 88% decrease in yield, there was an estimated loss of PhP30,800 in cash income in an estimated 500m^2 area with 1000 plants sold at PhP35 per kg of sweetpotato. In this case study however, reduction in yield was not due to sweetpotato fusarium wilt and there was high rainfall and very humid conditions prevailed during the cropping season which resulted to small root formation and eventually affecting farmer's income.

CONCLUSION AND RECOMMENDATION

The incidence of insect pests and diseases during the cropping period was affected by climatological factors like rain and humidity. High rainfall and humid conditions affected the canopy cover of the sweetpotato. As a consequence, storage root formation has been affected. The presence of leaf defoliators noted towards the harvest period did not significantly affect root formation hence not considered as economically important.

Climatic factors like rain has likewise attributed to the incidence of rotting during harvest. Variety tolerance was also seen in the minimal incidence of insect pests and diseases. Variety *Geslayan* is second to variety *swerte* that was identified by the farmers to have tolerance to insect pests and diseases.

Researches towards identification of resistant varieties can be considered as these diseases can satisfactorily be controlled with resistance. Likewise, regular field monitoring particularly on diseases should be strengthened and these can be done in participation with the Department of Agriculture and the Academe. Use and production of clean planting materials (CPM) for continuous supply can become a standard among farmers as these have an impact towards sustainable sweetpotato production.

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Appendix 1

List of key informants/workshop coordinators in Municipal Agriculture Office

List of Key Informants		
Name	**Position**	**Address**
1. Cherry L. Sano	Municipal Agricultural Officer	LGU-Atok, Benguet
2. Lolita Beganio	Agricultural Technologist	LGU-Atok, Benguet
3. Julia Mendoza	Agricultural Technologist	LGU-Bakun, Benguet
4. Georgina Mayo	Agricultural Technologist	LGU-Bokod, Benguet
5. Delfin D. Rufino	Municipal Agriculturist	LGU-Buguias, Benguet
6.Dr. Prudencio Pedro	Municipal Agriculturist	LGU-Itogon, Benguet
7. Nida Felicitas	Agricultural Technologist	LGU-Itogon, Benguet
8. Samuel Geking	Agricultural Technologist	LGU-Kabayan, Benguet
9. Geofrey B. Binaliw	Municipal Agriculturist	LGU-Kabayan, Benguet
10. Claire Pataras	Agricultural Technologist	LGU-Kabayan, Benguet
11. Dr. Peter Begawen Jr.	Municipal Agriculturist	LGU-Kapangan, Benguet
12. Freda Pacsi	Agricultural Technologist	LGU-Kapangan, Benguet
13. Denialyn Pis-et	Agricultural Technologist	LGU-Kibungan, Benguet
14. Rudy S. Daculan	Municipal Agricultural Officer	LGU-Mankayan, Benguet
15. Maribel Pinas	Agricultural Technologist	LGU-Mankayan, Benguet
16. Ramon M. Anacioco	Municipal Agricultural Officer	LGU-Sablan, Benguet
17. Arthur G. Mariano	Agricultural Technologist	LGU-Sablan, Benguet
18. Marlyn N. Cabanes	Municipal Agriculturist	LGU-Tuba, Benguet
19. Michelle T. Saingan	Agricultural Technologist	LGU-Tuba, Benguet
20.Jeoffrey D. Sotero	Municipal Agriculturist	LGU-Tublay, Benguet
21. Susan A. Lino	Agricultural Technologist	LGU-Tublay, Benguet
22. Manuel M. Tucay	Municipal Agriculturist	LGU-Bambang, Nueva Vizcaya
23. Angelo Ramos	Agricultural Technologist	LGU-Bambang, Nueva Vizcaya
24. Delia Cagungaw	Agricultural Technologist	LGU-Sta. Fe, Nueva Vizcaya
25. Ruth B. Damaso	Agricultural Technologist	LGU-Kayapa, Nueva Vizcaya
26. Rufin D. Fernandez	Municipal Agriculturist	LGU-Kayapa, Nueva Vizcaya

Appendix 2

List of workshop participants – sweetpotato, taro and yam growers

A. Naguey, Atok, Benguet			
Name	**Age**	**Sex**	**Agency/ Address**
1. Elpedia M. Alos		F	Egang, Naguey
2. Ester L. Biniahan		F	Sawingan, Naguey
3. Frida P. Bachangan	32	F	Sawingan, Naguey
4. Josie K. Laoyan	45	F	Despag, Naguey
5. Morenia D. Padsiko		F	Sawingan, Naguey
6. Myrna P. Badiwal	60	F	Sawingan, Naguey
7. Florina Aliknas	49	F	Casdan, Naguey
8. Jane S. Badival	64	F	Sawingan, Naguey
9. Richel D. Podaan	47	F	Sawingan, Naguey
10. Sofia K. Kimbongan	50	F	Casdan, Naguey
11. Didith M. Alsaen	34	F	Casdan, Naguey
12. Wilsa Palayao		F	Casdan, Naguey
13. Anabelle Kigis	39	F	Casdan, Naguey

Workshop interview and field work in Naguey, Atok

B. Tawangan, Kabayan

Name	Age	Sex	Agency/ Address
1. Mercy Lesino	30-<	F	Tawangan, Kabayan
2. Anghelita Payagen	51-60	F	Tawangan, Kabayan
3. Fatima Bugtong	30 - <	F	Tawangan, Kabayan
4. Rosa Ventura	51-60	F	Tawangan, Kabayan
5. Ernesta Alicnas	41-50	F	Tawangan, Kabayan
6. Noemi Lomesio	41-50	F	Tawangan, Kabayan
7. Victoria Flores	41-50	F	Tawangan, Kabayan
8. Hermina Laquito		F	Tawangan, Kabayan
9. Delin Nemo	51-60	F	Tawangan, Kabayan
10. Arsenia Cariño	30 - <	F	Tawangan, Kabayan
11. ryan Lestino	31-40	M	Tawangan, Kabayan
12. Linda Himbadan	41-50	F	Tawangan, Kabayan
13. Arlyn Molitas		F	Tawangan, Kabayan
14. Liza Dukis	31-40	F	TARC MPC
15. Sarcelia B. Bugtong	51-60	F	
16. Racquwl Masing	31-40	F	TARC MPC
17. Lolling Dimot	51-60	F	
18. Presilla Cospeh	31-40	F	TARC MPC
19. Rebecca Legligen	31-40	F	TARC MPC
20. Clara Adcasa	51-60	F	TARC MPC
21. Tito Himbadan	51-60	M	TARC MPC
22. Marjury S. Nemo	51-60	F	TARC MPC
23. Ana Dipo	30 - <	F	TARC MPC
24. Mary Claire P Pataras	31-40	F	OMAG - MLGU
25. Jedona M. Colongey	31-40	F	OMAG - MLGU

C. Sagubo, Kapangan		
Name	**Sex**	**Agency/ Address**
1. Dino Dimas Jr.	M	Bileng, Sagubo
2. Janette Ligao	F	Bileng, Sagubo
3. Melia Alcino	F	Landing, Sagubo
4. Brigida Awidan	F	Bileng, Sagubo
5. Jean Lamngad	F	Bileng, Sagubo
6. Dulnuan Apot	M	Bileng, Sagubo
7. Adela Awidan	F	Bileng, Sagubo
8. Agusta Alutang	F	Landing, Sagubo
9. Ana Fermin	F	Bileng, Sagubo
10. Zenaida Dennis	F	Bileng, Sagubo
11. Rosa Tawe	F	Bileng, Sagubo

Workshop interview and field work in Sagubo, Kapangan

D. Kibungan, Benguet		
Name	**Sex**	**Agency/ Address**
1. Brenda Fianza	F	Poblacion, Kibungan
2. Sonia Lid-ayan	F	Poblacion, Kibungan
3. Evelyn Tiw-ec	F	Poblacion, Kibungan
4. June Bilango	M	Badeo, Kibungan
5. Cadang Bagaste	M	Badeo, Kibungan
6. Olivia Baoad	F	Badeo, Kibungan
7. Grace Padino	F	Poblacion, Kibungan
8. Netzie Bacante	F	Badeo, Kibungan
9. Dolinda Banta	F	Poblacion, Kibungan
10. Cobita Oide	F	Polis, Poblacion
11. Susan Landican	F	Poblacion, Kibungan


Interview with sweetpotato, taro and yam growers in Kibungan and ocular visit to sweetpotato, taro and yam areas for pest assessment

E. Cabiten, Mankayan		
Name	**Sex**	**Agency/ Address**
1. Maribel M. Pina	F	LGU, Mankayan
2. Malone A. Olanio	M	Cabiten, Mankayan
3. Regina B. Tanacio	F	Cabiten, Mankayan
4. Benilda W. Martin	F	Cabiten, Mankayan
5. Nena Aguinas	F	Cabiten, Mankayan
6. Mariana Compas	F	Cabiten, Mankayan
7. Aser M. Gayag-o	M	Cabiten, Mankayan
8. Helen Libag	F	Cabiten, Mankayan
9. Marta Olanio	F	Cabiten, Mankayan
10. Nora Canggat	F	Cabiten, Mankayan


Interview with sweetpotato, taro and yam farmers in Mankayan, Benguet

F. Sablan, Benguet		
Name	Sex	Agency/ Address
1. Maria Valles	F	Kamog, Sablan
2. Mary Valles	F	Tenekey, Kamog, Sablan

Field work and workshop interview in Sablan; familiarization to the disease to stimulate sharing of information during the workshop

G. San Pascual, Tuba

Name	Age	Sex	Agency/ Address
1. Ricardo P. Jose	64	M	San Pascual, Tuba
2. Noemi Payuso	58	F	San Pascual, Tuba
3. Bernardo Benawe	57	M	San Pascual, Tuba
4. Alejandro B. Placido	60	M	San Pascual, Tuba
5. Myrna Sahoy	51	F	San Pascual, Tuba
6. Jocelyn Lay-on	47	F	San Pascual, Tuba
7. Paula B. Amolot	62	F	San Pascual, Tuba
8. Corazon B. Balanag	52	F	Tarong, San Pascual, Tuba
9. Jimmy Basilio	49	M	Tarong, San Pascual, Tuba
10. Romeo L. Ente	58	M	Apni, San Pascual, Tuba
11. Olivia B. Ayupan	60	F	Taba-ao, San Pascual, Tuba
12. Roberto M. Quero	46	M	Golo, San Pascual, Tuba
13. Rebeca C. Cariño	59	F	Ana-ao, San Pascual, Tuba
14. Denia F. Marigza	42	F	Payacpac, San Pascual, Tuba
15. Samuel K. Carintas	68	M	Apni, San Pascual, Tuba
16. Lorna S. Runas	46	F	Colon, San Pascual, Tuba
17. Flordelizo B. Abanes	48	M	Mago, Tuba

Workshop interview with ube farmers in San Pascual, Taloy Sur, Tuba

H. Taloy Norte, Tuba			
Name	**Age**	**Sex**	**Agency/ Address**
1. Nilda Wakat	54	F	Beles, Taloy Norte, Tuba
2. Marjorie Bad-ey	36	F	Bet-ang, Taloy Norte, Tuba
3. Greg Ortiga	44	M	Beles, Taloy Norte, Tuba
4. Lorna Milo	42	F	Bet-ang, Taloy Norte, Tuba
5. Charity Dapyawen	17	F	Bet-ang, Taloy Norte, Tuba
6. Cristina Dao-anes	51	F	Bet-ang, Taloy Norte, Tuba
7. Catalina W. Ortega	44	F	Bet-ang, Taloy Norte, Tuba
8. Lanie M. Pal-iwen	25	F	Bet-ang, Taloy Norte, Tuba
9. Helen M. Milo	67	F	Bet-ang, Taloy Norte, Tuba

Fieldwork in Taloy Norte, Tuba

I. Taloy Sur, Tuba

Name	Age	Sex	Agency/ Address
1. Hilda B. Galosi	61	F	Asinan, Taloy Sur, Tuba
2. Sonia W. Loquitan	64	F	Ba-wek, Taloy Sur, Tuba
3. Elesia T. Alilis	62	F	Caucalan, Taloy Sur, Tuba
4. Julita A. Paran	56	F	Asinan, Taloy Sur, Tuba
5. Lolita J. Lopez	60	F	
6. Ellen Q. Calawen	57	F	Asinan, Taloy Sur, Tuba
7. Cristola A. Alilis	80	M	Palina, Taloy Sur, Tuba

Workshop interview with ube farmers in Taloy Sur, Tuba

J. Basil, Tublay

Name	Age	Sex	Agency/ Address
1. Evangline Cando	39	F	Pangablan, Basil, Tublay
2. Marcelene Subdi	55	F	Pangablan, Basil, Tublay
3. Prescilla Contino	31	F	Pangablan, Basil, Tublay
4. Letecia Godio	32	F	Pangablan, Basil, Tublay
5. Sylvia Cayso	32	F	Pangablan, Basil, Tublay
6. Flora Baguling	54	F	Pangablan, Basil, Tublay
7. Nemesia C. Godio	76	F	Pangablan, Basil, Tublay
8. Merilyn L. Anas	49	F	Pangablan, Basil, Tublay
9. Prescela Albaro	48	F	Pangablan, Basil, Tublay
10. Brigida Mendoza	63	F	Pangablan, Basil, Tublay
11. Aurelia Cancho	49	F	Pangablan, Basil, Tublay
12. Bernadeth Subdi	60	F	Pangablan, Basil, Tublay
13. Marciana Cando	61	F	Pangablan, Basil, Tublay
14. Florentina Anas	60	F	Pangablan, Basil, Tublay
15. Emilia Alejandro	51	F	Pangablan, Basil, Tublay
16. Valeria Dampulay	63	F	Pangablan, Basil, Tublay
17. Serafina Busoy	44	F	Pangablan, Basil, Tublay
18. Carmen Basit	47	F	Pangablan, Basil, Tublay

19. Elizabeth Cayap	60	F	Pangablan, Basil, Tublay
20. Sofia Pataras	63	F	Pangablan, Basil, Tublay
21. Godofredo Rimando	43	M	Pangablan, Basil, Tublay
22. Marciana Zarate	47	F	Pangablan, Basil, Tublay
23. Josie A. Carpio	22	F	Pangablan, Basil, Tublay
24. Carmen C. Dampulay	47	F	Pangablan, Basil, Tublay

K. Bambang, Nueva Vizcaya

Name	Age	Sex	Agency/ Address
1. Elio C. Docio	51	M	Pallas, Bambang, Nueva Vizcaya
2. Vecinte Luyaman	68	M	Pallas, Bambang, Nueva Vizcaya
3. Warlit B. Denon	43	M	Pallas, Bambang, Nueva Vizcaya
4. Tinang Bugtong	40	F	Pallas, Bambang, Nueva Vizcaya
5. Loleng Santos		F	Pallas, Bambang, Nueva Vizcaya
6. Delia D. Calpasi	46	F	Pallas, Bambang, Nueva Vizcaya
7. Astrella D. Banih	42	F	Pallas, Bambang, Nueva Vizcaya
8. Sonia O. Dinggas	37	F	Pallas, Bambang, Nueva Vizcaya
9. Tessie D. Campoy	41	F	Pallas, Bambang, Nueva Vizcaya
10. Shonie Denon	36	F	Pallas, Bambang, Nueva Vizcaya
11. Beninda L. Luyaman	40	F	Pallas, Bambang, Nueva Vizcaya
12. Aida D. Decoran	49	F	Pallas, Bambang, Nueva Vizcaya
13. Angeline K. Bagiw	40	F	Pallas, Bambang, Nueva Vizcaya
14. Sabina D. Luyaman	41	F	Pallas, Bambang, Nueva Vizcaya
15. Jose Denon	72	M	Pallas, Bambang, Nueva Vizcaya
16. Padoni N. Dalmase	68	M	Pallas, Bambang, Nueva Vizcaya
17. Alfonso G. Gano	59	M	Pallas, Bambang, Nueva Vizcaya
18. Allones Apondi	50	M	Pallas, Bambang, Nueva Vizcaya

Focus group discussion with rootcrop growers and ocular inspection in Pallas, Bambang, Nueva Vizcaya for assessment of fusarium wilt and other pests sweetpotato

L. Kasibu, Nueva Vizcaya

Name	Age	Sex	Agency/ Address
1. Martha B. Orencia	30	F	Cordon, Kasibu, Nueva Vizcaya
2. Jean C. Nang-is	28	F	Cordon, Kasibu, Nueva Vizcaya
3. Sabina S. Ponhal	38	F	Cordon, Kasibu, Nueva Vizcaya
4. Arsenia A. Carlos	40	F	Cordon, Kasibu, Nueva Vizcaya
5. Alfredo Bungubung	56	M	Cordon, Kasibu, Nueva Vizcaya
6. Sheila May D. Orenia	28	F	Cordon, Kasibu, Nueva Vizcaya
7. Ronalyn N. Ramos	24	F	Cordon, Kasibu, Nueva Vizcaya
8. Mary Jane P. de Vera	42	F	Cordon, Kasibu, Nueva Vizcaya
9. Rosita B. Mencias	44	F	Cordon, Kasibu, Nueva Vizcaya
10. Janis B. Sabado	39	F	Cordon, Kasibu, Nueva Vizcaya

Interview with rootcrop growers in Kasibu, Nueva Vizcaya

M. Kayapa, Nueva Vizcaya

Name	Sex	Agency/ Address
1. Melto Cupaac	M	Pinayag, Kayapa
2. Juaqina Colas	F	Banao, Kayapa
3. Dorina Balahyak	F	Latbang, Kayapa
4. Lilia Abiadew	F	Latbang, Kayapa
5. Juaqin Alfredo	M	Nansiakan, Kayapa
6. Wilfredo Sibaen	M	Cabayo, Kayapa
7. Adne Bugtong	M	Amelong-Labeng
8. Jose Rhani Lagundino	M	Acacia, Kayapa
9. Pio Sinacay	M	Talecabcab, Kayapa
10. Santos Pawisan	M	Cabayo, Kayapa
11. Conia Antonio	F	Cabayo, Kayapa
12, Anderson Tomas	M	Banao, Kayapa
13. Danny Pacia	M	Buyasyas, Kayapa
14. Herson Tactac	M	Pangawan, Kayapa
15. Welhilmina Nisperos	F	Pampang, Kayapa
16. Teresa Litawan	F	Binalian, Kayapa

17. Adelina Panas	F	Binalian, Kayapa
18. Franklin Eliseo	M	Tubongan, Kayapa
19. Dario Bugtong	M	Buyasyas, Kayapa
20. Julios Dudon	M	Besong, Kayapa
21. Lorena, Bencio	F	Tubongan, Kayapa
22. Helen Bugnay	F	Kayapa Proper East, Kayapa
23. Vilma Wakit	F	Besong, Kayapa
24. Celia Gumangan	F	Besong, Kayapa
25. Percilyn Dodon	F	Besong, Kayapa
26. Nagey Macasling	M	Besong, Kayapa
27. Linda Nayusan	F	Besong, Kayapa
28. Talen Cabangon	F	Besong, Kayapa
29. Conching Gumbatan	F	Amelong-Labeng, Kayapa
30. Lita Luis	F	Amelong-Labeng, Kayapa
31. Martina Balacay	F	Amelong-Labeng, Kayapa
32. Delia Luis	F	Amelong-Labeng, Kayapa

N. Sta. Fe, Nueva Vizcaya

Name	Age	Sex	Agency/ Address
1. Delia B. Cagunao	62	F	MAO
2. Adelma F. Cayap	45	F	ATBU
3. Minerva E. Litawan	65	F	ATBU
4. Processo B.Mallna	65	M	Buyasyas, Sta. Fe, Nueva Vizcaya
5. Antonio C. Dumalo	68	M	Bantina, Sta. Fe, Nueva Vizcaya
6. Ben L. Balalong		M	Canabuan, Sta. Fe, Nueva Vizcaya
7. Liwan B. Wasit	39	M	ATBU
8. Marivis S. Alfonso	50	F	Zigzag, Poblacion, Sta. Fe, Nueva Vizcaya
9. Erminio K. Mallana	54	M	Buyasyas, Sta. Fe, Nueva Vizcaya
10. Cadongga L. Ceghan	60	M	Bacneng, Sta. Fe, Nueva Vizcaya
11. Alex B. Tindaan	63	M	ATBU
12. Charity M. Casem	40	F	Baliling, Sta. Fe, Nueva Vizcaya
13. Roy Alos		M	Buyasyas, Sta. Fe, Nueva Vizcaya
14. Gydabelle B. Liwan		F	Tactac, Sta. Fe, Nueva Vizcaya
15. Porfirid C. Yasay Jr.	42	M	
16. Wilma B. Bataan	62	F	Bacneng, Sta. Fe, Nueva Vizcaya
17. Bella S. Acheta	61	F	Villaflores, Sta. Fe, Nueva Vizcaya