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Surveillance of *Phytophthora Spp* Disease on Pineapple at Specific District of Ethiopia

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Abstract

One of the tropical fruits with high economic value is pineapple. Smooth cayenne (smooth leaf) and Red Spanish (Rough leaf) are the two cultivars of pineapple grown in the world. They grow in the soil and resemble epiphytes in that their roots are intolerant of poor soil aeration. Pineapple plantation has several limitations, especially diseases caused by *Phytophthora spp*. (called hear rot or root rot). *Phytophthora spp*. is known as water molds that require free water for distribution or movement from one place to other places. It infects the basal leaf tissues and roots of pineapple plants. Surveillance was conducted at Sidama (Aleta Chuko and Dara districts) and Kefa (Gojeb private farm) zones along main and feeder roads in order to know its status. Previously the presence of root rot caused by *Phytophthora spp* was reported by Jima Agricultural Research center in 2010. According to this report, it seemed difficult to export fresh pineapple fruits to abroad. The objective of this survey was in order to check on the absence or presence, and distribution of the disease in the major pineapple growing areas of the two zones. Out of 36 inspected pineapple farmer fields, heart rot disease caused *Phytophthora spp* was recorded on 4 (11.11%) fields. It was recorded at Sidama and Kefa zones. Among 33 observed pineapple farmer fields in Sidama zone, heart rot was observed on 1 (3.03%) field at Aleta Chuko district, in Dibicha location. Similarly, out of 3 observed pineapple fields of private farm in Kefa, heart rot was recorded on 3 (100%) fields at Ginebo district, in Gojeb locality. Among 4 heart root infected pineapple fields, 75% (3 fields) of the disease was recorded on smooth cayenne pineapple type while 25% (1 field) of the disease was recorded on Red Spanish type. Root rot disease distribution on smooth cayenne at Horizon private farm was very high, and 15-20% of pineapple plants are seriously damaged (infected). Therefore, Pineapple planting materials from this area should be restricted to other potential pineapple growing areas. Moreover, integrated disease management options will be applied in order to tackle this disease with proper Phytophthora species identification.

Keywords: *Phytophthora Spp*; Pineapple; Red Spanish; Smooth Cayenne; District

Introduction

Pineapple (*Ananas comosus*) is one of the most important fruit crops in the world. It originated in South America, where native people selected a seedless mutation from a wild species. Pineapple was domesticated more than 3,500 years ago (Brown, 2010) [1]. It belongs to the family Bromeliaceae, many members of which are epiphytes living on trees and rocks. Pineapples grow in the soil and resemble epiphytes in that their roots are intolerant of poor soil aeration. Smooth cayenne (smooth leaf) and Red Spanish (Rough leaf) are the two cultivars of pineapple grown in the world. But smooth cayenne dominates the industry (Bartholomew, 2003) [2]. The pineapple plant is a short, Perennial, herbaceous monocot about 1m (3.3ft) in height. The plant has a peduncle (stem) on which the fruit develops. The pineapple yields many products in addition to the edible fruit. Crude extracts from the fruit, stem, and leaves yield several proteinases (Lee *et al.*, 1997) [3]. Fiber extracts from pineapple leaf is processed into paper, cloth, and composite plastics (Hepton and Hodgson, 2003) [4]. Pineapple is also highly suited to the production ornamental varieties.

Some diseases such as fungi, bacteria, nematodes and viruses are constrained on pineapple production and productivity. *Phytophthora cinnamomi* is the most widely distributed fungal disease that attacks wide host ranges such as Avocado (*Persea amaericana*), Pineapples (*Ananas comosus*), *Castanea, Cinnamomum, Coniferales, Ericaceae*, (including *Rhododendron sp*.), *Eucalyptus, Fagus, Juglans, Quercus* and other many ornamental trees and shrubs. It causes root and heart rot of those plants.

Phytophthora spp. is known as water molds that require free water for distribution or movement from one place to other places. It infects the basal leaf tissues and roots of pineapple plants. The genus *Phytophthora* is now commonly classified as Stramenopiles, members of a phylum in the kingdom Chromista (Agrios, 2005) [5]. Stramenopiles are similar to fungi but several important differences. The most common of these species on pineapple *are Pythium arrhenomanes*, *Phytophthora cinnamomi, Phytophthora parasitica* (Bartholomew, 2003) [2]. *Phytophthora* may form zoospores, swimming spores with whip-like tails called flagella. Attracted by root exudates, they navigate through water in the soil towards the roots of pineapple plant. Other *Phytophthora* propagules (Chlamydospores, mycelia, oospores) may be disseminated by draining soil water in soils attached to tools, foot wear, and vehicle tires. These may be splashed up to pineapple crowns to cause heart root in the basal white tissues. The oospores and chlamydospores formed by *Phytophthora* can remain dormant and survive in the soil for many years.

Phytophthora infected pineapple plants showing different symptoms on the plant parts. These include soft rooting of the basal white tissues of the youngest leaves at the heart of the apical meristem. Infected leaves may be pulled from the plant readily, and as disease progresses sufficiently, plants die. On fruit-bearing plants of susceptible varieties, the infection can move up through the fruit peduncle and rot the fruit. A slow plant growth rate may be an initial indication of root rot. Other symptoms include chlorosis (yellowing), browning of the leaves, which may then eventual curl and die. Stem and leaf rot develop after the leaves have become discoloured due to the root destruction (Sideris, 1930) [6]. Root necrosis is another good indicator of the disease. To check for root necrosis, grasp the crown and tug. Healthy plants will remain firmly anchored in the ground. Plants affected with root necrosis may be easily pulled from the soil. In Ethiopia, the major pineapple growing areas are Sidama and Kefa zones. For the first time, it was introduced 50 years ago by religious missionary in to Sidama zone of Southern nations and nationalities of People (SNNP). More than 3480 farmers are engaged in pineapple cultivation on the 4384 hectares at both zones. There are still many non-cultivated hectares that are suitable for pineapple farming (SZAO, 2017). Survey was conducted at Sidama (Aleta Chuko and Dara districts) and Kefa (Gojeb private farm) zones. Previously the presence of root rot caused by *Phytophthora spp* was reported by Jima Agricultural Research center (2010) at Gojeb Horizon Plc farm especially on newly introduced Smooth Cayenne. According to this report, it seems difficult to export fresh pineapple fruits to abroad. Specific survey was done at above mentioned pineapple growing potential areas. Hence, the objective of this surveillance was in order to gather data on the absence or presence, and distribution of *Phytophthora spp* disease in the major pineapple growing areas of the two zones.

Material and Method

Description of the Study Area

The assessment was conducted in Southern Nations and Nationalities of People (SNNP), at Sidama and Kefa Zones, in 2017. Disease diagnosis at laboratory was done at Ambo Plant Protection Research Center (APPRC). APPRC is located at 08^0 96' 885" N latitude and 37^0 85' 923" E longitudes and at an altitude of 2147m.a.s.l. The annual average temperature and rain fall is 27.54 ^oC and 1077.68 mm, respectively.

Pineapple field survey

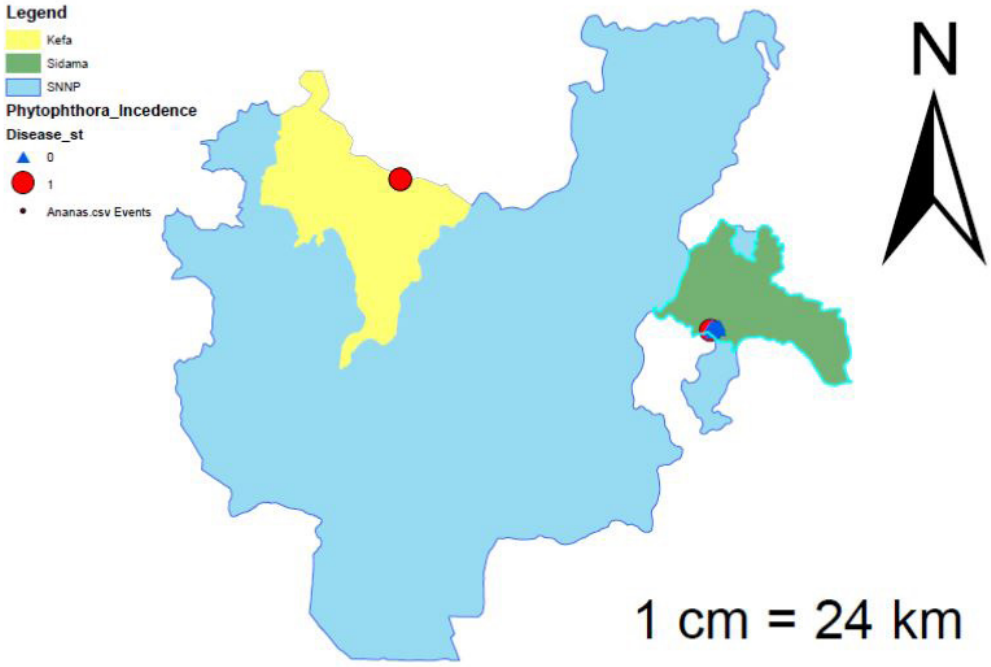

Figure1: Map showing presence (1) or absent (0) of Phytophthora disease in Kefa and Sidama Zones

The survey was covered 3 major pineapple growing districts of Aleta Chuko and Dara (Sidama); and Ginebo (Kefa) zones (Figure 1). The assessment was focused on previously suspected fungal pathogen which is *Phytophthora spp* as specific survey. The trip composition was 2 researchers (pathology and entomology) from APPRC, and 1 protectionist from Minister of Agriculture and Natural Resources (MOANR). Disease (present or absent) and GPS (elevation, latitude and longitude) data were collected using already prepared survey format. Environmental factors such as temperature and relative humidity were also taken by using thermo hygrometer. We were inspected 36 pineapple fields (33 farmer fields and 3 private farm fields). The survey was conducted following main and feeder roads on pre-planned routes in areas where Pineapple is predominantly grown. The inspection was done along the two diagonals (in an ''X" pattern). We were discussed with farmers by raised different questions on pineapple types, previously disease occurrence, and management options, in order to grasp additional information. We took 12 pineapple samples in order to check the problems at laboratory whether it is diseased or not by growing on the potato dextrose agar and microscopic observation of its structure (Figure 2). The samples collected in the paper bags were tagged with the name of Zone, district, variety and date of collection.

Selection of major Pineapple growing districts

The districts were selected based on pineapple growing coverage areas that was obtained from MOANR, Sidama and Kefa Zonally agricultural offices of SNNP. Farmer fields were selected systematically and 1 farmer from pineapple growing union (association) was move together with us as a leader of inspection areas. He was supported us by showing good roads, major pineapple growing areas, and by translated local language in to national language (Amharic). Disease prevalence was calculated as follows.

$$\textbf{Disease prevalence (\%)} = \frac{\text{No. of infected fields X 100}}{\text{Total number of fields assessed}}$$

Data Analysis and Interpretation

Survey information was analysed by using the descriptive statistical analysis, on disease present or absent. The survey result also supported by laboratory diagnosis (by culturing on artificial media and then morphological characterization using growth habit on the Potato dextrose Agar and microscopic observation its structure).

Results and Discussion

Out of 36 inspected pineapple farmer fields, heart rot disease caused *Phytophthora spp* was recorded on 4 (11.11%) fields. It was recorded at Sidama and Kefa zones (Table 1). Among 33 observed pine apple farmer fields in Sidama zone, *Phytophthora* disease was observed on 1 (3.03%) field at Aleta Chuko district, in Dibicha location (Appendix 1).

Farmer Name (Farm name)	Region	Zone	District	Location	Elevation (m.a.s.l))	GPS data		Environmental factors		Disease status	Pineapple type
						Latitude (N)	**Longitude (E)**	**Tem (Oc)**	**RH (%)**		
Mruso Muae	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1556**	**06'29.497**	**038'16.838**	**27.7**	**35**	+	**Red Spanish**
Blayneh Batola	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1604**	**06'29.679**	**038'17.735**	**29.3**	**35**	-	**Red Spanish**
Teshome Baranga	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1647**	**06'30.161**	**038'18.994**	**28.9**	**37**	-	**Red Spanish**
Tagese Mute	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1628**	**06'29.923**	**038'18.364**	**27.7**	**40**	-	**Red Spanish**
Shurubie Direga	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1555**	**06'29.674**	**038'17.113**	**28.1**	**28**	-	**Red Spanish**
Gale Gebesa	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1540**	**06'29.679**	**038'16.796**	**29.2**	**32**	-	**Red Spanish**
Tadesse Shae	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1514**	**06'29.299**	**038'16.342**	**29.1**	**30**	-	**Red Spanish**
Tamerat Mekonene	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1588**	**06'29.885**	**038'17.713**	**31.5**	**32**	-	**Red Spanish**
Teshale Tenegega	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1567**	**06'30.115**	**038'17.910**	**29.1**	**27**	-	**Red Spanish**
Shunea Garemo	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1587**	**06'29.761**	**038'17.596**	**36.9**	**29**	-	**Red Spanish Red Spanish**
Asetateke Dayano	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1615**	**06'29.845**	**038'17.861**	**25.5**	**33**	-	**Red Spanish**

Farmer Name (Farm name)	Region	Zone	District	Location	Elevation (m.a.s.l))	GPS data		Environmental factors		Disease status	Pineapple type
Asefaw Arata	**SNNP**	**Sidama**	**Aleta Chuko**	**Dibicha**	**1633**	**06'30.057**	**038'18.825**	**27.2**	**28**	-	**Red Spanish**
Ayele Banato	**SNNP**	**Sidama**	**Aleta Chuko**	**Teso**	**1627**	**06'30.610**	**038'18.239**	**28.2**	**32**	-	**Red Spanish**
Tesema hairbayo	**SNNP**	**Sidama**	**Aleta Chuko**	**Teso**	**1610**	**06'30.645**	**038'18.139**	**28.8**	**30**	-	**Red Spanish**
Kebede Muae	**SNNP**	**Sidama**	**Aleta Chuko**	**Teso**	**1641**	**06'30.004**	**038'18.659**	**26.6**	**28**	-	**Red Spanish**
Kechila Gabiso	**SNNP**	**Sidama**	**Aleta Chuko**	**Teso**	**1681**	**06'31.002**	**038'19.092**	**30.6**	**36**	-	**Smooth Cayene**
Degne Da-bana	**SNNP**	**Sidama**	**Aletachuko**	**Teso**	**1671**	**06'30.711**	**038'19.130**	**27**	**29**	-	**Red Spanish**
Lema Meto	**SNNP**	**Sidama**	**Aleta Chuko**	**Teso**	**1630**	**06'30.586**	**038'18.492**	**28.7**	**30**	-	**Red Spanish**
Awedo Berasa	**SNNP**	**Sidama**	**Aleta Chuko**	**Teso**	**1628**	**06'30.793**	**038'18.397**	**33**	**29**	-	**Red Spanish**
Tesfaye Sefato	**SNNP**	**Sidama**	**Aleta Chuko**	**Teso**	**1629**	**06'30.891**	**038'18.475**	**29.4**	**30**	-	**Red Spanish**
Alemu Boredo	**SNNP**	**Sidama**	**Aleta Chuko**	**Gambella**	**1591**	**06'31.006**	**038'17.394**	**28.2**	**26**	-	**Red Spanish**
Tesema Yierdaw	**SNNP**	**Sidama**	**Aleta Chuko**	**Gambella**	**1622**	**06'30.579**	**038'17.465**	**26.6**	**34**	-	**Red Spanish**
Alemu Gebisa	**SNNP**	**Sidama**	**Aleta Chuko**	**Gambella**	**1570**	**06'30.286**	**038'16.903**	**32.5**	**31**	-	**Red Spanish**
Yosef Beriso	**SNNP**	**Sidama**	**Aleta Chuko**	**Gambella**	**1556**	**06'30.390**	**038'16.517**	**27.1**	**33**	-	**Red Spanish**
Kayamo Bango	**SNNP**	**Sidama**	**Dara**	**Safa**	**1639**	**06'29.421**	**038'19.162**	**22.9**	**41**	-	**Red Spanish**
Tamrat Kayamo	**SNNP**	**Sidama**	**Dara**	**Safa**	**1641**	**06'29.280**	**038'19.123**	**26.4**	**38**	-	**Red Spanish**
Tamange Tesfaye	**SNNP**	**Sidama**	**Dara**	**Safa**	**1622**	**06'29.245**	**038'18.611**	**20.3**	**46**	-	**Red Spanish**
Zerihun Menegesha	**SNNP**	**Sidama**	**Dara**	**Safa**	**1594**	**06'29.018**	**038'18.076**	**23.3**	**45**	-	**Red Spanish**
Yohanse Shopana	**SNNP**	**Sidama**	**Dara**	**Safa**	**1557**	**06'28.726**	**038'17.562**	**25.5**	**32**	-	**Red Spanish**
Teshome Hamaro	**SNNP**	**Sidama**	**Dara**	**Safa**	**1532**	**06'28.612**	**038'17.125**	**26.2**	**33**	-	**Red Spanish**
Memeru Yebure	**SNNP**	**Sidama**	**Dara**	**Safa**	**1573**	**06'28.818**	**038'17.774**	**27.8**	**35**	-	**Smooth Cayene**
Shiferaw Kimebita	**SNNP**	**Sidama**	**Dara**	**Safa**	**1638**	**06'29.357**	**038'19.014**	**25.1**	**28**		**Red Spanish**
Kebede Yohanse	**SNNP**	**Sidama**	**Dara**	**Safa**	**1625**	**06'29.349**	**038'19.509**	**28**	**27**	-	**Red Spanish**
Horizon pineapple plantation (private)	**SNNP**	**Kefa**	**Ginebo**	**Gojeb**	**1450**	**07'25.240**	**036'21.330**	**20.5**	**58**	+	**Smooth Cayene**
Horizon pineapple plantation (private)	**SNNP**	**Kefa**	**Ginebo**	**Gojeb**	**1446**	**07'25.304**	**036'21.462**	**27**	**41**	+	**Smooth Cayene**
Horizon pineapple plantation (private)	**SNNP**	**Kefa**	**Ginebo**	**Gojeb**	**1391**	**07'25.197**	**036'21.655**	**32**	**33**	+	**Smooth Cayene**

+ is Present; - is Absent; SNNP is Southern nations and nationality of people

Appendix 1:- Survey information in the major pineapple growing areas of SNNP, 2017

Zone	District	Location	No. of fields observed	Variety type	Altitude range (m.a.s.l)	Disease status
Sidama	Aleta Chuko	Dibicha	12	Red Spanish	1514-1647	Present at 1 field only
		Teso	8	Red Spanish except 1 field	1610-1681	No disease recorded
		Gambella	4	Red Spanish	1556-1629	No disease recorded
	Dara	Safa	9	Red Spanish	1532-1641	No disease recorded
Kefa	Ginebo	Gojeb	3	Smooth Cayene	1391-1450	Disease was present on 3 inspected pineapple fields
Total (Range)			36		1391-1681	

Table1: Status of *Phytophthora spp* in the major pineapple growing areas of SNNP, in 2017.

Similarly, out of 3 observed pineapple fields of private farm in Kefa, heart rot was recorded on 3 (100%) fields at Ginebo district, in Gojeb locality (Table 1; Appendix 1; Figure 3). Among 4 heart root infected pineapple fields, 75% (3 fields) of the disease was recorded on smooth cayenne pineapple type while 25% (1 field) of the disease was recorded on Red Spanish type. This survey result is in line with Jima Agricultural Research Center (JARC) report in 2010 that pineapple root rot was widely distributed specially on the smooth cayenne varieties as compared to Red Spanish. According to this report, the smooth cayenne which were newly introduced from Kenya and South Africa were highly affected followed by local smooth cayenne whereas the damage on red Spanish was less as compared the two pineapple varieties.

Phytophthora spp growth on the Potato dextrose Agar (PDA) was very slow and it took 15-20 days in order to observe its structures through microscope. Colony morphology of *Phytophthora spp* isolates was described as rosaceous, petaloid or non-pattern (Figure 2). Non-pattern classification was given to those isolates that did not display any characteristic pattern as described by Erwin and Ribeiro (1996) [7]. Those *Phytophthora spp* were identified from pineapple root and soil samples.

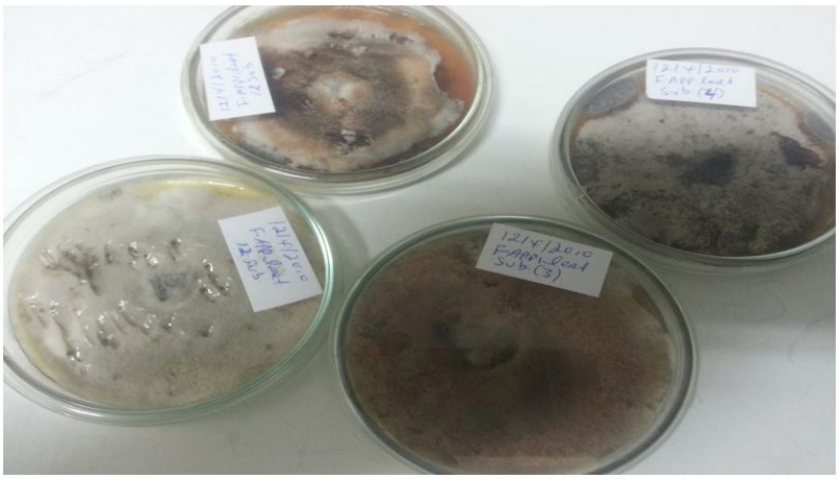

Figure 2: Morphological growth character of *Phytophthora spp* on PDA, at APPRC

Figure 3: Pineapple plants infected with *Phytophthora spp* disease at Gojeb, Kefa zone

Conclusion and Recommendation

Except Horizon private farm at Kefa zone, pineapple plantation in the survey areas have been relatively free from *Phytophthora spp* disease. Root rot disease distribution on smooth cayenne at Horizon private farm was very high, and 15-20% of pineapple plants are seriously damaged (infected). It can be transmitted through infected planting material and farm tools, and can develop in to high severity level. Pineapple planting materials from this area should be restricted to other potential pineapple growing areas. The source of planting material must be carefully selected and inspected. It must be ensure that disease-free plating material should always be used. Pineapple heart and root rots are most severe in high-rainfall areas and irrigated soils with poor soil drainage. So, care should be taken when selecting areas for pineapple plantation.

Effective management of *Phytophthora* diseases should be an integration of regulatory, cultural, chemical, and biological practices. Proper management practices including the following should be used to prevent serious outbreaks of *Phytophthora spp.*

1. Site selection: Pineapple root rot occurs most frequently in high-rainfall areas with poor soil drainage. Drier areas with good soil drainage are preferred because of the reduced chance of root rot caused by *Phytophthora*. This can be achieved through careful field selection, constructing drains to intercept run-off before it reaches the plantation, constructing drains within the field so that water is removed rapidly without causing erosion, and installing underground drain. Acidic soils are preferred to alkaline soil for inhibiting water molds (Bartholomew, 2003) [2].
2. Exclusion, sanitation: An important part of plant disease prevention is to avoid the introduction of pathogen inoculum to an uninfested area. Farm tools, farming machinery, containers, media, or planting material contaminated with soil from off site should be cleaned and disinfested before use.
3. Field scouting and sanitation: Remove infected plant material from the field whenever practical and take care not to move infested soil in to uninfested areas.
4. Cropping systems: Limiting soil compaction and increasing soil aeration by tilling will stimulate root growth and limit water retention, thus helping to prevent root rot. Crop rotation will benefit pineapple production by reducing levels of inoculum (from oospores and chlamydospores), but benefits may be limited because of the wide host range of *Phytophthora*. Raised beds or mounds at least 20 cm high may increase production cost but may lead better drainage and reduce the chance of infection (Sideris, 1930) [6]. Well-drained soils are essential for minimizing the risk of *Phytophthora* infection.
5. Biological control: Existing bacteria, fungi, and other microorganism in the soil will compete with *Phytophthora*.
6. Resistant varieties: Use of resistant pineapple planting material is environmental safe disease control methods and best control strategy for resource poor farmers.
7. Disease free planting materials: Do not transplant pineapple plants displaying symptoms of root or heart rot.
8. Pesticides: Fungicides, while effective, represent increased production costs and should only be used when necessary. When applying fungicides after planting, important considerations including environmental conditions like high rainfall and fields that have a history of disease. Pre-plant dips, foliar applications, and soil drenches of systemic fungicides are the most effective means preventing or reducing crop disease (Rohrbach, 1985) [8]. The crown is dipped in a fungicide before planting in the field. Two common systemic fungicides used against *Phytophthora* are Ridomil (mefenoxam) and Fosphite (Phosphonate) [9].

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