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Prevalence of banana *Xanthomonas* wilt in Nithi, Tharaka-Nithi County in Kenya

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ABSTRACT

Banana (Musa spp.) is a nutrient rich crop grown in small and large scale across the globe. It is rich in carbohydrates, vitamins and minerals thus, it may serve as the source of nutrition in low resourced regions such as Tharaka Nithi County, Kenya. However, banana production in many areas is faced with biotic constraints such as banana Xanthomonas wilt (BXW) disease caused by Xanthomonas campestris pv. musacearum. The pathogen attacks photosynthetic leaves and young fruits, reducing palatability and marketability. There is currently scanty information on prevalence of BXW in Nithi region of Tharaka Nithi County. Additionally, it remains unclear whether farmers in the region are knowledgeable on occurrence of BXW disease, symptoms and management practices. The prevalence of BXW was assessed through survey method in five villages (Kiang'ondu, Marima, Mitheru, Kibumbu and Giampampo) in Nithi. Percentage BXW prevalence in the studied villages was not significantly different (p>0.05). However, slightly higher BXW prevalence value of 21.14% was recorded at Giampampo village and was lower at Mitheru 11.24%. There was significant relationship (X^2 (8, N = 46) = 19.93, p= 0.0034) between banana variety grown and occurrence of banana diseases. There was significant relationship (X^2 (8, N = 46) = 31.165, p = 0.0053) between banana variety grown and susceptibility to diseases. The relationship between years of growing banana in the same farm and occurrence of banana diseases was significant (X^2(6,N= 46) = 8.761,p= <0.0001. The relationship between occurrence of banana diseases and season of the year was significant (X^2(8,N= 46) = 32.4591, p= <0.0001). The relationship between occurrence of banana diseases and management option in Nithi was significant (X^2(4,N= 46) = 6.9758,p= 0.0025). Majority of the farmers (92%) were unaware of existence of BXW in the region. Farmers expressed lack of knowledge on managing BXW diseases in their banana farms with the majority not being able to identify common diseases of banana. Based on these observations, there is need to educate farmers on best banana farming practices, disease identification and management.

Key Words: *Banana, Xanthomonas-wilt, Tharaka-Nithi and Kenya*

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I. Introduction

Banana (*Musa spp.*) is one of the most grown food crops globally, taking the fourth position after maize, rice and wheat (FAOSTAT, 2018). Banana is an important dietary source of carbohydrates and vitamins (Tripathi et al., 2010; Dotto et al., 2020) and other nutrients including potassium, proteins and fats (Joan et al., 2012; Serrem et al., 2020). Further, banana is a source of income for many rural households (Kamal et al., 2014; Voora et al., 2020). India is the largest producer of bananas globally, with 31million metric tons per annum (p.a) followed by China with about 12,075,238 metric tons per annum and Philippines with 8,645,749 tons p.a (Tripathi et al., 2010; Dale et al., 2017; Greenfield, 2020). In Kenya, bananas are produced by small and large-scale farmers, mainly for the local market and household consumption (Okoko et al., 2019). Regionally, Meru County takes the first position in banana production (19%), Kirinyaga County takes the second position (14%) while Embu takes the third position (12%). Other bananas producing counties includes- Tharaka Nithi (6%), Bungoma (5%), Kakamega (5%), Kisii (6%), Nyamira (5%), Taita Taveta (9%) Migori and Homa Bay Counties (5%), Muranga at 7% (Agwara, 2017).

Despite its nutritional and economic importance, the production of bananas is threatened by a variety of biotic and abiotic factors that include pests and diseases (Orr and Nelson, 2018; Nansamba et al., 2020). Some of the diseases that constrain banana production in the world are *Fusarium* and *Xanthomonas* wilts (Dale et al., 2017). Banana *Xanthomonas* wilt (BXW) is caused by *Xanthomonas campestris* pv. *Musacearum* (Kwach, 2012). Fruit symptoms include internal discolouration and premature ripening, while the inflorescence gradually wilts and yellow accompanied by shrivelling of male buds and bracts (Dale et al., 2017). The disease may cause up to 100% banana yield loss photosynthesis activity of the leaf is reduced (Tushemereirwe et al., 2003; Ochola et al., 2015).

The BXW is, a major, constrain in banana production globally and has been reported in African countries such as Uganda, Tanzania as well as Kenya (Ocimati et al., 2013a; Blomme et al., 2014; Nakato et al., 2018). In East Africa, economic losses due to BXW range from $2 to $8 billion (Abele and Pillay, 2007; Nkuba et al., 2015). In Kenya, BXW is widely spread and has been reported in Teso, Bungoma and Busia, Bumula, Yala, Bondo, Siaya, Mumias, Butere, Kisumu and Mt Elgon areas (Tripathi et al., 2007; Mbaka et al., 2009; Onyango et al., 2012; Kwach et al., 2012; Geberewold and Yildiz, 2019). However, information on the occurrence and distribution of the disease in other regions of Kenya, such as Tharaka Nithi County is limited. Knowledge of BXW occurrence in the County can be useful in development of its management strategies (Tripathi and Tripathi, 2009). The objective of this study was to determine the prevalence of BXW and gather information on farmer's knowledge and disease management practices in selected villages in Nithi region of Tharaka Nithi County in Kenya.

II. Materials and Methods

The area of study

The study on banana *Xanthomonas* wilt was carried out in Tharaka Nithi County in Kenya within the Nithi region, comprising Maara and Chuka Igambang'ombe Sub Counties. Tharaka Nithi County borders Embu, Nyeri, Kitui and Meru Counties (Figure 01). Tharaka Nithi County is divided into 4 sub-counties: Maara, Tharaka North, Tharaka south and Chuka IgambaN'gombe. The study was specifically carried out in Chuka Igambang'ombe with the altitude of 5200m and Maara with an altitude of 600m (Jaetzold et al., 2007).

Sampling procedure and sample size

Study on *Xanthomonas* wilt of banana in the farms was done using cross sectional survey method. Selected banana farmers and farms were visited once and information regarding banana varieties grown, occurrence of banana diseases in the farm, banana variety susceptible to diseases, duration for which banana has been growing in the same farm, season in which banana diseases is common, disease management method used by the farmer and lastly, farmers knowledge on banana *Xanthomonas* wilt was also enquired. Farm survey on selected farms for the actual occurrence of *Xanthomonas* wilt of banana was done using transects laid across the farm. The villages surveyed included Maara village, Mitheru village, Giampampo village, Kibumbu village and Kiangondu village. The questionnaires were administered to the 46 farmers. Out of 46 farmers, 15 farms were randomly picked for actual farm survey for BXW with three farms in every village. The five villages above were

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selected purposefully for the study since they are main banana producing areas in Maara and Chuka Igambang'ombe Sub-Counties with farms measuring 0.5 acres and above were estimated to be 100.

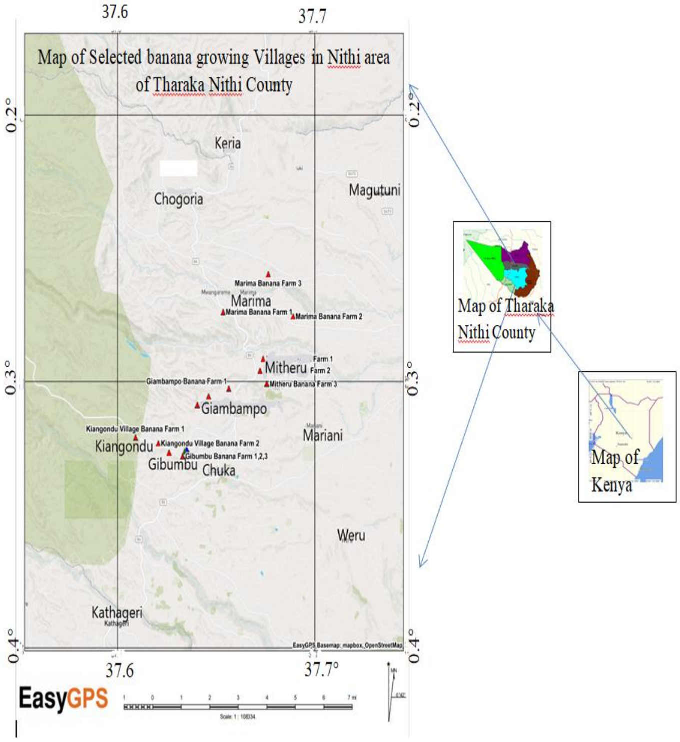

Figure 01. Map of Tharaka Nithi County showing study area

Evaluation of prevalence of banana *Xanthomonas* wilt

Symptoms of BXW were identified and disease was scored on a scale of 1-7 (Muhinyuza et al., 2007; Hashim and Mabagala 2016): where 1= no symptom, 2= yellowing leaves, 3= wilted leaves, 4= dry male buds with no wilting symptoms, 5= wilted banana leaves on banana mat and dry male bud, 6 = heavily wilted leaves, drying or dried male bud and premature fruit ripening and 7= yellow leaves necrosis. A banana mat includes the parent plant and its suckers (Stool). The Global Positioning System (GPS) was used to mark the altitude, latitude, and longitude of sampling locations.

Percent disease prevalence was calculated using the formula below.

$$\text{Disease prevalence} = \frac{\text{Number of individual ratings}}{\text{Total number of banana assessed}} \times \frac{100}{\text{Maximum scale}}$$

Data analysis

Data obtained on the prevalence of *Xanthomonas* wilt was subjected to one-way analysis of variance in SAS version 9.4 at 5% probability level. Prevalence data were log transformed ($\log_{10}$) to meet the requirement for analysis of variance. Data collected using a questionnaire on diseases aspects were analysed using Chi-square test of independent at 5% significant level.

III. Results

Prevalence of banana *Xanthomonas* wilt

There was no significant difference (p>0.05) between the five villages concerning BXW prevalence. Prevalence at Giampampo was 21.14% followed by Kiang'ondu village 17.54%. Mitheru village had the least prevalence of 11.24% (Table 01). The overall mean for the prevalence was 15.09% and only 3 villages (Giampampo, Marima and Kiang'ondu) recorded prevalence above the overall mean (Table 01).

The banana infected by *Xanthomonas* produced yellow pigmented exudates on cutting the pseudostem, the leaves were yellowish while the banana bunch had poorly developed banana fruits (Plate 01)

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Table 01. Prevalence of *Xanthomonas* banana wilts in selected villages in Nithi

Village	BXW Prevalence (%)
Giampampo	21.14
Kiang'ondu	17.54
Marima	15.49
Kibumbu	12.14
Mitheru	11.24
Mean	15.095
LSD (p≤0.05)	1.743
CV (%)	30.856

Banana *Xanthomonas* wilted plant | ***Xanthomonas* effect on banana bunch** | ***Xanthomonas* Yellow exudates on psuedostem**

Plate 01. Observed symptoms of banana *Xanthomonas* wilt

Varietal effect on disease occurrence

The relationship between banana variety grown and occurrence of banana diseases was significant (X2 167 (8, N = 46) = 19.93, Cramer's V = 0.4654, p= 0.0034). Twenty five percent (25%) of the respondents who grow mainly Kiganda and Israel banana variety reported disease occurrence in their farm. Twenty percent (20%) of the respondents who grow mainly Kampala banana variety reported disease occurrence on their farm. Seventy-five percent (75%) of farmers who could not tell the variety of bananas they grow reported diseases on their farm. Lastly, seventy six percent (76%) of farmers who grow mixed varieties reported banana diseases in their farms (Figure 02).

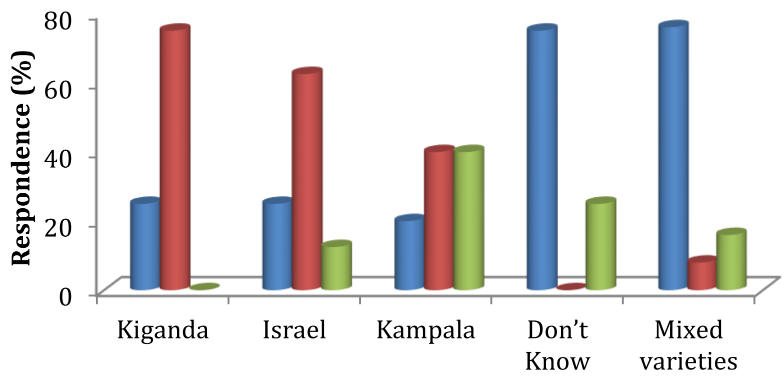

Figure 02. Relationship between banana variety growth and occurrence of diseases in the farm

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Banana variety growth and susceptibility to diseases in Nithi

There was significant relationship (X^2 (8, N = 46) = 31.165, p = 0.0053) between banana variety grown and susceptibility to diseases. A hundred percent (100%) of farmers who grow purely Kiganda, eighty eight percent (88%) of Israel growing respondents, eighty percent (80%) of farmers who purely grow Kampala, seventy five percent of respondents who lacks knowledge on variety that they grow and sixteen percent (16%) of farmers who grow mixed varieties reported that they did not know variety susceptible to banana diseases (Figure 03)

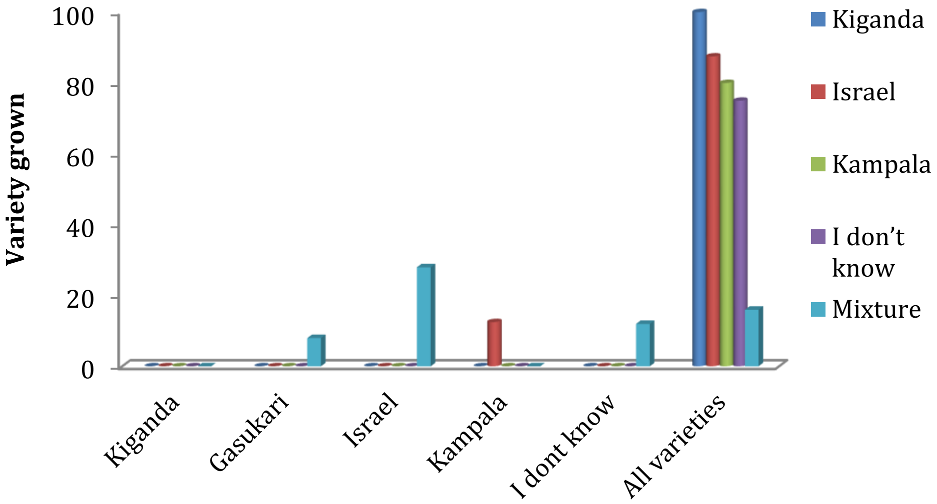

Figure 03. Graph of banana variety grown by farmers and susceptibility

Prevalence of banana diseases based on years of growing banana on the same farm

The relationship between years of growing banana in the same farm and occurrence of banana diseases in Nithi was significant (X^2(6, N= 46) = 8.761, p= <0.0001). Thirty-three percent (33%) of farmers growing banana for 1-3 years reported disease occurrence. Farmers that have grown bananas for between 4-7 years, fifty percent (50%) reported banana diseases in their farm. On the other hand, twenty three percent (23%) of farmers that have grown bananas for over ten years did not report the occurrence of banana diseases in their farms, while eight percent (8%) of farmers who have grown bananas for over ten years do not know whether banana diseases occurred in their farm (Figure 04).

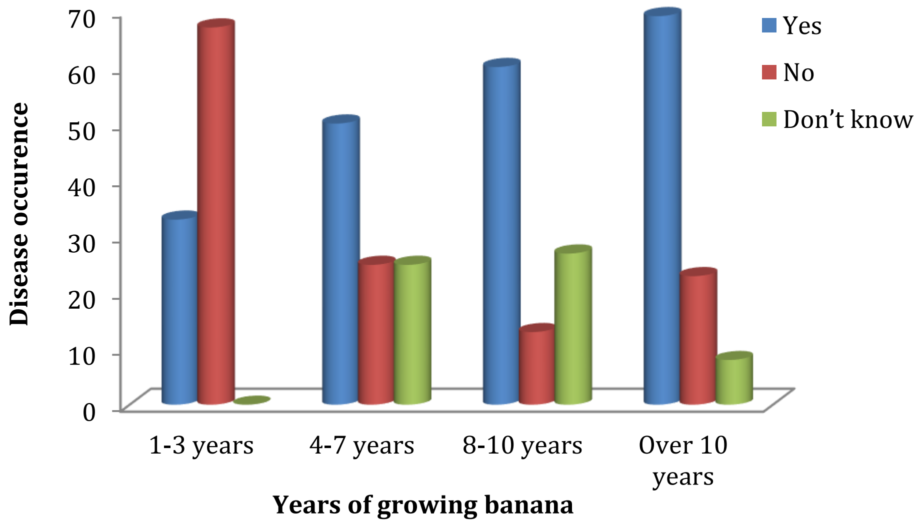

Figure 04. Association between years of growing bananas in the same farm and disease

Disease occurrence across different seasons of the year in Nithi

The relationship between occurrence of banana diseases and season of the year was significant (X^2(8, N= 46) = 32.459, p= <0.0001). Sixty five (65%) of farmers who reported banana diseases in their farms noted that diseases were most common during the dry season. Sixty three (63%) of farmers reported no knowledge of disease occurrence and season that diseases are common (Figure 05).

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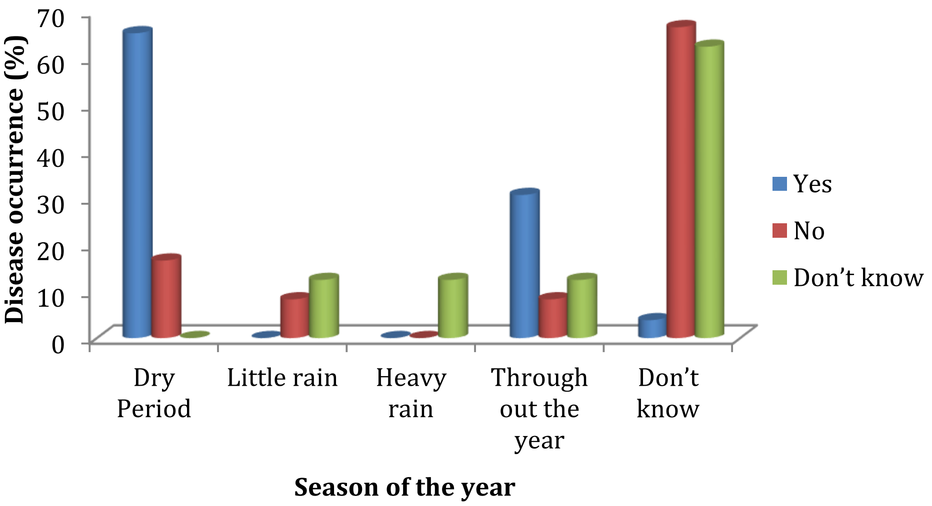

Figure 05. Association between season of the year and occurrence banana diseases

Disease management methods applied for different banana diseases

The relationship between occurrence of banana diseases and management option in Nithi was significant ($X^2(4, N= 46) = 6.9758, p= 0.0025$). Out of the total number of farmers who reported disease occurrence in their farms, nineteen percent (19%) uproots diseased tuber to control the diseases, fifteen percent (15%) apply chemicals to control the diseases, while sixty six (66%) do not do anything to control diseases (Figure 06).

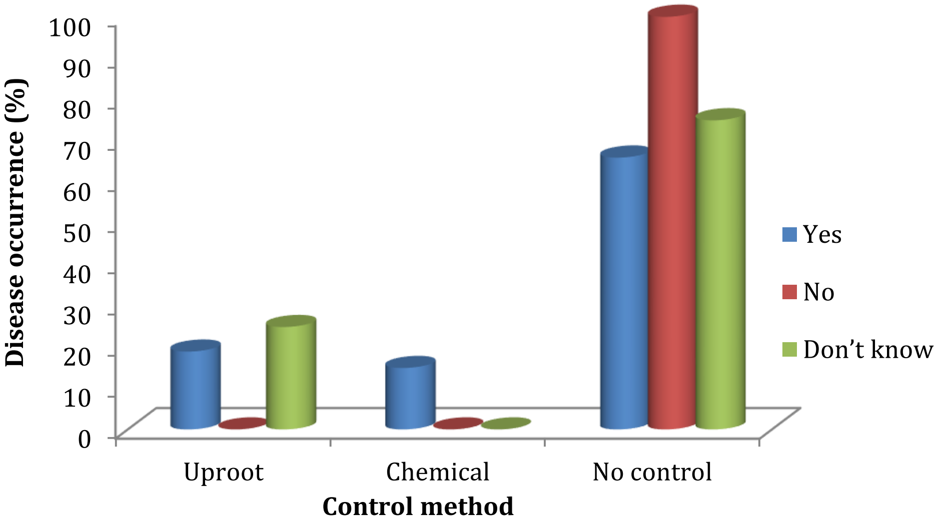

Figure 06. Disease management methods applied for different banana diseases in Nithi

Farmers knowledge of banana *Xanthomonas* wilt in Nithi, Tharaka Nithi County

The results indicated that relationship between occurrence of banana diseases and knowledge of *Xanthomonas* wilt of banana was significant (X^2 (2, N= 46) = 6.212, p= 0.0448). Out of the total number of farmers who reported diseases in their farms, ninety two percent (92%) lack knowledge of *Xanthomonas* wilt of banana while eight percent (8%) have knowledge of *Xanthomonas* wilt of banana. Hundred percent (100%) of farmers who did not know whether diseases occur on their farm also reported no knowledge of *Xanthomonas* wilt of banana (Figure 07).

IV. Discussion

Prevalence of *Xanthomonas* wilt in Nithi

Xanthomonas wilt of banana was observed in most of the farms surveyed. Prevalence of *Xanthomonas* differed from one village to the next, with Giampampo having higher severity mean of 21.14% and Mitheru village recorded the lowest severity. According to Jaworski and Hilszczański (2013) and

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Mwangi et al. (2006), areas below 1700 m above the sea level have many insects that may contribute in rapid spreading of the disease across farms. The closeness of banana farms in the area of study, may also be a contributing factor for an increased incidence of *Xanthomonas* wilt (Uwamahoro et al., 2019). Since the survey was conducted during the wet season, the observed prevalence values may be attributed to precipitation. Higher precipitation has been pointed out as the prevailing factor in occurrence of *Xanthomonas campestris* pv. *Musacearum* pathogen (Biruma et al., 2007). For instance, farms have been observed to experience higher *Xanthomonas* wilt prevalence during rainy season, unlike during drier seasons (Biruma et al., 2007). Precipitation encourages *Xanthomonas* pathogen survival, spore production, spore germination, multiplication and dispersion (Kang et al., 2010; Aung et al., 2018).

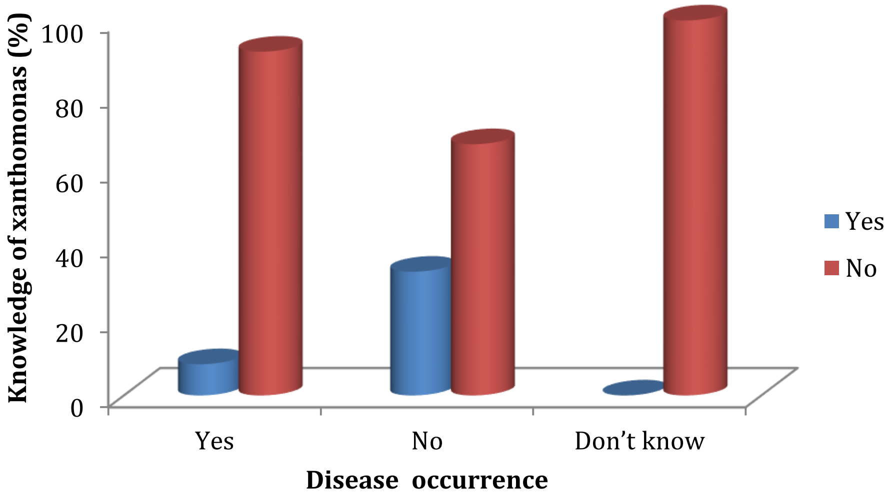

Figure 07. Knowledge of banana *Xanthomonas* wilt and disease occurrence in banana farms in Nithi, Tharaka Nithi County.

Effect of banana variety on occurrence of banana *Xanthomonas* wilt

Chi square test on the relationship between banana variety grown and occurrence of banana diseases in Nithi was significant $X^2(8, N= 46) = 19.93$, $p= 0.0034$ ($\alpha = 0.05$). Majority of farmers were found to grow mixed banana varieties and reported the highest number (76%) of banana diseases. The results of this study are similar to those of Uwamahoro et al. (2019). According to Tooker and Frank (2012), genetically diverse banana cultivars attract various categories on insects' pollinators that hasten disease spread.

Banana variety grown and their susceptibility to diseases in Nithi

Chi-square test results indicated that relationship between banana variety grown and susceptibility to diseases was significant $X^2(20, N= 46) = 31.165$, $p<0.0001$($\alpha = 0.05$). However, response on banana perceived to be susceptible was varied among the interviewed farmers. This study supports the result of Ocimati et al. (2013b) that most bananas cultivated are susceptible to diseases. Most susceptible ones lack persistent bracts that minimize pathogen infection naturally (Lewis et al., 2010). According to Mwangi and Nakato (2007), flowers of some banana varieties are less attractive to diseases vectors or may not be easily penetrated by the bacterium, minimizing infection.

Prevalence of banana diseases with age of the plants

Chi square test indicated that relationship between years of growing banana in the same farm and occurrence of banana diseases in Nithi was significant $X^2(6, N= 46) = 8.761$, $p= <0.0001$($\alpha = 0.05$). According to Ocimati et al. (2019), some suckers in a mat may be free of pathogen despite the parent sucker showing *Xanthomonas* wilt symptoms. Likewise, in cases where parent banana plants may not succumb to *Xanthomonas* wilt, some of its suckers might be attacked by the diseases.

Disease occurrence across different seasons of the year

Chi-square test of independence indicated that relationship between occurrence of banana diseases and season of the year in Nithi was significant $X^2(8, N= 46) = 32.4591$, $p= < 0.0001$ ($\alpha = 0.05$). Sixty five percent (65%) of farmers reported that banana diseases mostly occur during the dry season. Sixty three (63%) of farmers reported no knowledge of disease occurrence and season that diseases are common. Observation from most respondents that banana diseases occur mostly in dry season correlate with those of Tushemereirwe et al. (2004). However, results differed from those of Ewané et al. (2013). Favorable conditions promote pathogen reproduction, development and pathogen persistence (Ochola et al., 2015). The development of bacteria wilt associated with the bacteria that affects the plant xylem, may be significantly increased by water deficit (McElrone et al., 2001). Increased temperature due to drought may lead to the breakdown of resistance genes that are sensitive to heat in plants (Gijzen et al., 1996; Bonnett et al., 2002; Younis et al., 2020) and it can be difficult to discriminate between effects on host resistance genes and effects on pathogen virulence.

Disease management methods applied for different banana diseases

The chi-square test showed that relationship between occurrence of banana diseases and management option was significant ($X^2(4, N= 46) = 6.9758$, $p = 0.0025$, ($\alpha = 0.05$)). Sixty six percent (66%) of the respondents who reported diseases on their farm do not apply any control mechanism. These results are supported by Rutikanga et al. (2013) report but differed from those of Hashim (2013) where majority of farmers reported cutting down once infected. Farmers tend to ignore disease occurrence favoring persistence of the pathogen in the farm (Rutikanga et al., 2013). Infected pseudo stem remains a potential source of inoculums and a key factor in spreading banana diseases (Shimwela et al., 2016; Ocimati et al., 2019). According to Bagamba et al. (2006), due to fear of losing income from bananas, farmers may not be willing to uproot the infected bananas even when infected. Disease management is important in regulating the pressure of infection on farms. Prevention of diseases on the farm requires concerted effort to prevent pathogen entry and spread. Thus, sterilization of equipment, timely removal of infected plants is necessary (Biruma et al., 2007; Blomme et al., 2017). Regular use of farm equipment that is not sterilized is likely to increase the frequency of disease occurrence, particularly during the wet season (Blomme et al., 2014).

Farmer knowledge of banana *Xanthomonas* wilt

The relationship between occurrence of banana diseases and knowledge of *Xanthomonas* wilt of banana in Nithi was significant (X^2 (2, N = 46) = 0 6.212, p = 0.0448). Out of the total number of farmers who reported disease occurrence, Eight percent (8%) knew *Xanthomonas* wilt of banana while (92%) reported a lack of knowledge of *Xanthomonas* wilt of banana. Thirty-three percent (33%) of farmers who reported no diseases in their farms had knowledge of *Xanthomonas* wilt and the rest did not know. These results on knowledge of *Xanthomonas* wilt of banana differ from those of Uwamahoro et al. (2019) in which majority of the respondents were aware of *Xanthomonas* wilt of banana.

V. Conclusion

Prevalence of banana *Xanthomonas* wilt differed from one village to the next and was slightly higher in Giampampo was21.14% though the differences were not statistically significant (p>0.05). The variety of bananas, according to the farmer, influences the occurrence of diseases in banana farms. , The majority of farmers (66%) in the study area, do not do anything to control banana diseases in their farms. The majority of farmers, are not aware of existence of *Xanthomonas* wilt of banana. Based on these observations, there is a need to educate farmers on best banana farming practices, disease identification and management.

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