INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 11, No. 1, p. 69-75, 2017
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Identification and analysis of factors in management of banana fungal diseases: Case of Sigatoka (*Mycosphaerella fijiensis*. Mulder) and *Fusarium* (*Fusarium oxysporum* f. sp. cubense (Foc) diseases in Arumeru District

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Article published on July 21, 2017

Key words: Fungal diseases, Sigatoka, Fusarium wilt, ICT.

Abstract

In recent years, the application of Information and Communication Technology (ICT) in agriculture, governance and education has indicated positive impact in terms of efficiency. However, this potential has not been fully exploited by banana crops farmers in managing banana diseases (Sigatoka and *Fusarium* wilt diseases), that cause low productivity in bananas. A survey on banana diseases was conducted in Arumeru district located in Arusha region, Tanzania. The study aimed at analyzing the two banana fungal diseases and the weather factors influencing them for the purpose of developing an early warning system for management of banana fungal diseases. Data were collected using self-administered questionnaires to farmers and extension officers, and from two weather stations (Enza Zaden Africa Ltd and Tengeru Met Station Arumeru). The results from analysis indicated that 94% of farmers agree on the existence of banana fungal diseases in their farms. The farmers lack knowledge of fungal diseases, a fact acknowledged by 89% of farmers while 11% of farmers have traditional knowledge. Again Eighty-six percent (86%) of the farmers do not apply any method to either prevention or management of banana diseases while 14% apply some disease management and preventive measures against banana fungal diseases. The results obtained from analysis of weather information will be used in the development of an early warning system to help banana farmers around Arumeru district to make the right decision on disease management aspects and apply them at a right time using available resources, which will ultimately improve banana yield.

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Introduction

Plantains and bananas are a staple food for about 70 million people throughout the humid and sub- humid tropic of Africa (Etebu & Young-Harry, 2011). The crop is largely produced by small-holder farmers, with around 85% of the global production destined for local markets and only 15% entering the International trade (Ordonez, Seidl, Waalwijk, Drenth, & Kilian, 2015). The East African region (including Tanzania) is the largest producer and consumer of bananas in Africa, with Uganda being the second largest producer in the world after India (Tripathi *et al.,* 2009). However, its yield isaffected by diseases (Gallez *et al*., 2004).

Banana is among crops that are affected by several fungal diseases (Surridge, Viljoen, Crous, & Wehner, 2003). In most cases, Sigatoka and *Fusarium* are the mainly reported diseases responsible for significant losses in banana yield (Ganry *et al*., 2012).

The black Sigatoka disease is caused by air borne fungal pathogen whereas the *Fusarium* wilt disease is caused by a soil borne pathogen (Chillet *et al*., 2009; Deltour *et al*., 2017; Gutierrez-Monsalve *et al*., 2015). Both diseases are widely spread throughout where the banana crop is cultivated. Control for such pathogens in the field is virtually impossible due to methods of their spread and survival (Deltour *et al*., 2017).

The changes in weather condition have been reported to influence both leaf spot (Sigatoka) and wilt (*Fusarium* Wilt) fungal diseases incidences and severity, in the agricultural system (Ghini, Bettiol, & Hamada, 2011). Small holder farmers mostly rely on their own long time experience to predict the effect of weather on agricultural activities in resource constrained areas including Tanzania. This leads to poor quality and quantity of production. The timely access to relevant information is the limiting factor.

ICT solutions for agriculture using mobile phone technology have the potential for addressing challenges for smallholder farmers in resource constrained areas including Tanzania. An automated computer vision technique for detection of Banana Bacterial Wilt and Sigatoka diseases was developed and tested in Uganda for early disease detection (Owomugisha *et al*., 2014). M-Farm is a text message based mobile phone application which provides smallholder farmers in Kenya with up-to-date crop price information and assists farmers to search for markets of their products (Mfarm, 2010). I Cow is a text message and voice-based mobile phone application for small-scale dairy farmers in Kenya (Icow, 2013). iCow provides dairy farmers information on cow breeding, animal nutrition, milk production and gestation.

Weather information is gathered on daily basis at various weather stations in Tanzania. Fig. 1. indicates the distribution of weather stations in Tanzania. However, the utilization of the weather information by smallholder banana farmers and extension officers for early warning on banana fungal diseases is not clear.

We propose to make use of the weather data to develop an early warning system (using a mobile application) to enable farmers better manage and control the incidence of the banana fungal diseases. Hence, this study aims at exploring the relationship between weather conditions and banana fungal diseases, awareness of the diseases among the farmers and preventive measures taken (if any) and to check if the extent of the diseases is real exists in the selected area of study.

The second section of the paper presents a methodology that was deployed in this study. This is followed by results and analysis in the third section. The discussions and conclusion focused on the analysis of key factors that are responsible for causing banana fungal diseases.

Material and methods

Study Area

This study was conducted in Arumeru District in Arusha Region, Tanzania during the season of the year 2016/17 in the month of December 2016 to February 2017. The study involved two wards with six villages; Nkoaranga (which have Ngyani, Nshupu and Nkoaranga villages) and Akheri (that include Nguruma, Patandi and Akheri villages).

Respondents

Data was collected using self-administered questionnaires distributed to sixty-seven (67) farmers and four (4) extension officers selected at random for data collection. Weather data obtained from two weather stations close to the villages, namely Enza Zaden Africa Limited and Tengeru Meteorological station Arumeru No.9336035.

Data collection tools

A data collection tool was developed using open data kit (ODK) which is an open source platform for data collection that uses mobile devices to collect data on the field server (Anokwa, Hartung, & Brunette, 2009). The use of ODK tool for data collection was efficient and enabled to overcome associated challenges on data processing including difficulties in the analysis, cleaning data and on time error detection.

Statistical Analysis

R statistical analysis application and Google sheet tools were used for analysis to provide descriptive statistics in terms of frequencies and percentages for insights on banana fungal diseases.

Percentages reported corresponding to the total number of farmers and extension officers answering the individual questions. The statistical significance of relationships among selected variables was determined using the Chi-square test with a p-value of 0.05 as the level of significance.

Results

Demographic characteristics of respondents

Demographic characteristics of respondents involved in this study were as follows 67 farmers, 4 extension officers and 2 experts from weather stations which make a total of 73 respondents. Fig. 1 and Fig. 2 summarizes the composition of all respondents for this study. The study went further to investigate on respondents' education level. Results show that 54% of respondents had primary education, 3% had adult education, 37% had secondary education and 6% had university/college education.

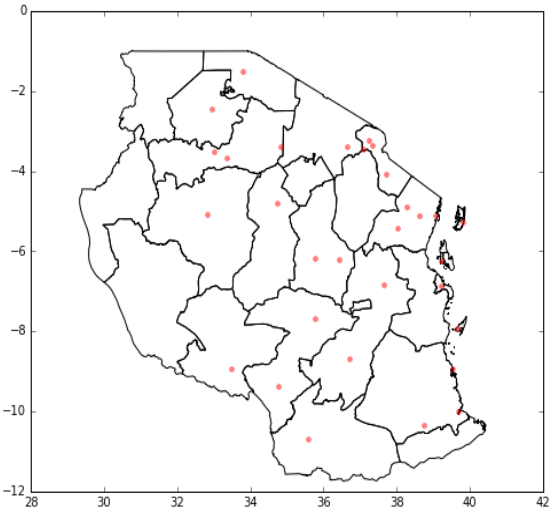

Fig. 1. Weather stations distribution for Tanzania. (Source: NOAA Global Historical Climatology, 2016).

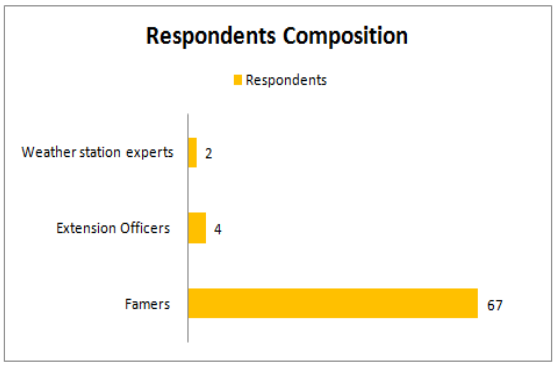

Fig. 2. Respondents composition.

Respondents' awareness of diseases and prevention measures

When asked about their awareness (knowledge about the diseases) on the diseases, 89% of respondents said they do not have any knowledge on banana fungal diseases and 11% were found to be aware of those banana fungal diseases (Table 1).

When asked about disease management and preventive measures, 86%revealed that they do not apply any disease management and prevention measures against banana fungal diseases, only 14% apply somelocally feasible prevention and management measures (like pruning banana trees, totally cutting off the banana plant, usage of ashes etc) for both Sigatoka and *Fusarium* wilt (Table 1).

Table 1. Respondents' awareness of diseases and prevention measures.

Evaluation Criteria	Respondent category and Other response			
	Farmers (%)		Extension officer (%)	
	Yes/Agree	No/Disagree	Yes/Agree	No/Disagree
Existence of Banana fungal diseases	94	6	100.00	0.00
Awareness: Knowledge on fungal diseases	11	89	100.00	0.00
Any preventive/management measures in use	14	86	25.00	75.00

Rate of Sigatoka and Fusarium diseases per village

The study revealed that Sigatoka and *Fusarium* diseases do exist in the study area but the rate of these diseases differ from village to village (Fig. 3). This was caused by several factors like knowledge on those diseases (Fig. 4), disease preventive measures or management (Fig. 5), and education level of the farmers residing in that villages (Fig. 6 and Fig. 7),.

Also, poor coordination among the extension officers and farmers was found to be a big challenge. The result of chi-square test shows that collaboration among extension officers and farmers is significant (p = 0.026).

Also, we found out that, there are several indigenous prevention and management ways on Sigatoka and *Fusarium* wilt diseases. This included: pruning banana leaves, cutting and uprooting of the whole banana plant, use of ashes etc are commonly used in some villages and they are not scientifically proved and might have negative impacton soil borne fungal pathogen like *Fusarium* spp (Fig. 8 and Fig. 9). One of the major drawbacks of these ways is that most of them involve killing/uprooting of the plant completely (Fig. 8 and Fig. 9).

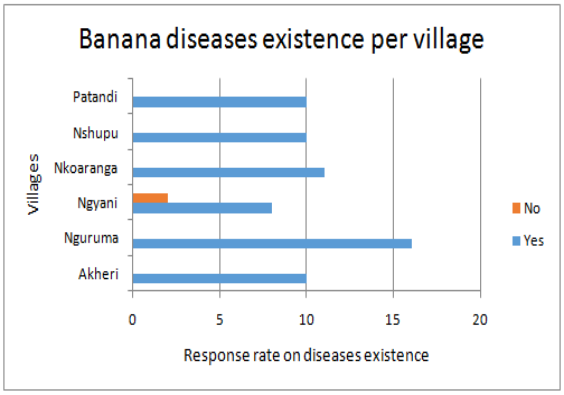

Fig. 3. Rate of Sigatoka and *Fusarium* diseases per village.

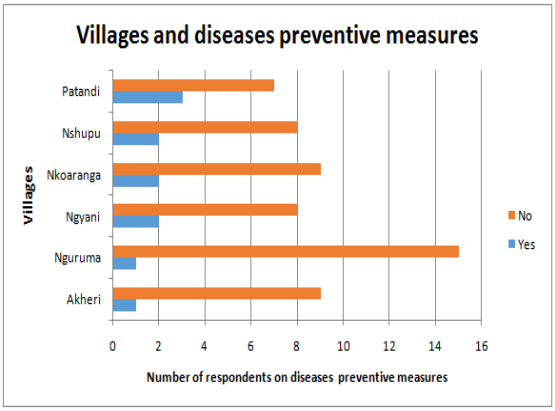

Fig. 4. Preventive/management measures of Sigatoka and *Fusarium* diseases per village.

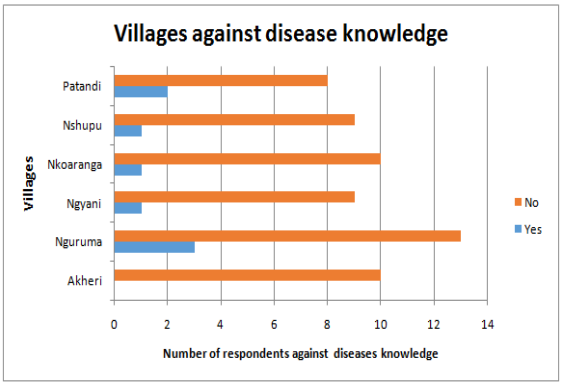

Fig. 5. Knowledge of Sigatoka and *Fusarium* diseases per village.

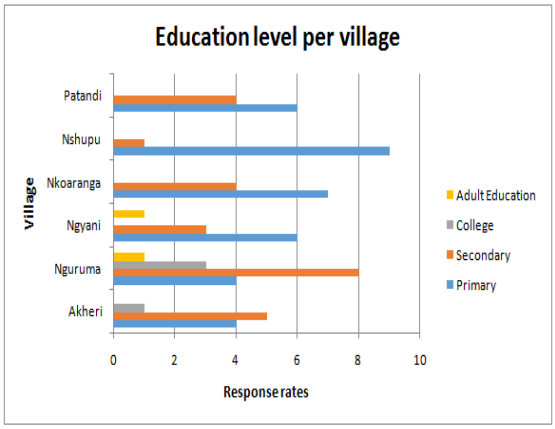

Fig. 6. Farmers education level per village.

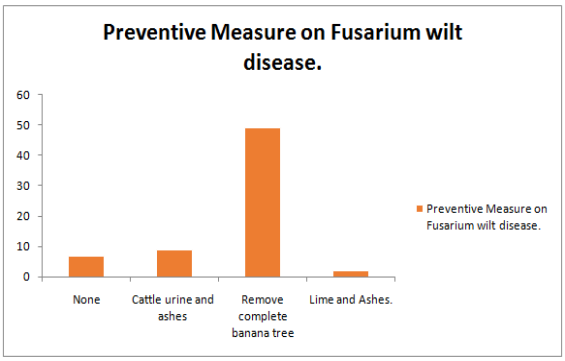

Fig. 7. Preventive Measure on *Fusarium* Wilt disease.

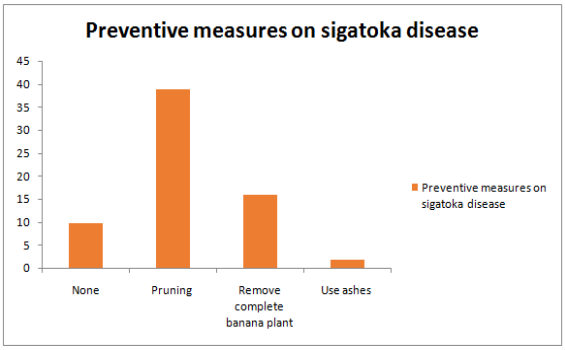

Fig. 8. Preventive Measure on Sigatoka disease.

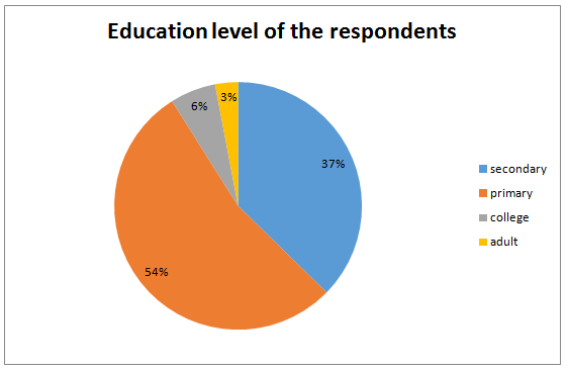

Fig. 9. Education level of the respondents.

Discussion

The results from this study reveal that banana's farmers in Arumeru district, Arusha region, Tanzania are still facing a lot of challenges regarding banana's fungal diseases. First, the existence of banana fungal diseases is still high, second, preventive and management measures of those diseases is still poor among them, Although there are farmers use traditional ways of preventing and managing those diseases which is not efficiency enough, third, knowledge of banana fungal diseases and education level among farmers per villages is still very low which hinder the effort of preventing and managing fungal diseases as shown in Fig. 5, 6 and 9.

Two fundamental goals drove the collection of the data and the subsequent data analysis. The goals were to assess the awareness in preventive measures and management of banana fungal diseases among the farmers and to understand the key factors associated with fungal disease development for the purpose of developing an early warning tool. These objectives were accomplished. This study agrees with other studies on different factors. Different studies (Pérez-vicente and Dita 2014; Pérez-Vicente 2012; Kijazi *et al.*, 2013) revealed that there is a relationship between daily accumulated rainfall and the speed of the development of the diseases in early weeks. Other studies also revealed that different factors like humidity, temperature and wind speed are responsible for causing different banana fungal diseases (Pérez-Vicente 2012; Ganry *et al.*, 2012; Salaudeen *et al.*, 2016).

The study done by Pérez-Vicente reported a high correlation between the duration of leaf wetness and the speed of development of the disease four weeks later in Cavendish banana (Pérez-Vicente, 2012). Also, rainfall (daily accumulated in 10 and 14 days). Also, other studies report that the curve of the amount and duration of rainfall accumulated for periods of 10 and 14 days has a predictive value of the speed of development of the disease four and five weeks later in Cavendish banana and plantains respectively (Marín *et al.* 2003; Surridge *et al.*, 2003; Kumakech *et al.*, 2015). Furthermore, coordination between farmers and extension officers was found to be poor. This was caused by several factors like the ratio of extension officers to farmers. Study was reveals that there is only one extension officer per village. This is not sufficient in relation to the task and their importance in those areas.

Conclusion

In this paper analysis of factors associated with banana fungal diseases for Arumeru district in Arusha, Tanzania is presented.

Findings from this study have been found to be consistent with findings from other authors in other geographical locations reported in several related studies on banana fungal diseases. In addition, the impact of various weather data and from the questionnaire was explored. Data findings were reported as descriptive statistics on study variables on awareness of diseases, awareness on management and preventive measures, the rate of reported cases of Sigatoka and *Fusarium* fungal diseases and education level of farmers. These factors are fundamental inputs for the development of an early warning system for banana fungal diseases.

Acknowledgements

Authors extend their appreciation to extension officers from Arumeru district specifically two wards known as Akheri and Nkoaranga for their support during the survey. Furthermore, we are grateful to weather stations instructors at Tengeru Met Station and Enza Zaden Africa Ltd for providing historical weather data. We extend appreciation to VLIR Project for providing research funding.

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