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ABSTRACT

Potato (*Solanum tuberosum* L.) is a starchy tuber crop that is widely cultivated in Africa as an income generator. Nutritionally, potato provides essential amino acids among other important body required nutrients. Despite the significance of potato as a crop, its production is constrained by various biotic and abiotic factors, which includes bacterial wilt caused by *Ralstonia solanacearum*. *Ralstonia solanacearum* is widely distributed in tropical, sub-tropical and warm temperate climates with a wide host range. In Kenya, the infection of potato farms by *R. solanacearum* has spread to all potato growing areas. It affects over 70% of potato farms causing yield losses of between 50 to 100% in Kenya. This study was carried out to assess the occurrence of bacteria wilt in small scale farmer's potato farms in Runyejes in Embu County. A survey of potato farms was conducted in different tomato growing villages in between September and October 2019. Diseased potato samples and soil samples were collected from the farms and taken for laboratory study at Chuka University. Collected data on incidence of pathogen on tuber and soil were subjected to one way analysis of variance (ANOVA) in SAS version 9.4. Significance means of all the analysis were separated using Least Significance Difference at $\alpha = 0.05$. Incidences of potato bacteria wilt disease in different villages surveyed was significantly different ($p < 0.05$). The incidence of *R. Solanacearum* in farmer's fields ranged from 16.51% (Makutano village) to 50.42% (Kiangodu village). The overall mean score for the incidence was 32.2% across all the farms studied. In conclusion, incidence of bacterial wilt pathogen in soil and tuber sampled from Runyenjes area of Embu County differ from farm to farm and location to location. Study on incidence of potato bacterial wilt in is necessary in all small potato farmers in Embu County to determine the extent of spread of the disease in the area.

Key words: Bacterial Wilt, Soils and Potato Tubers, Runyenjes, Kenya

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is a starchy tuber crop grown in over 125 countries and is a staple food to over one billion people (FAOSTAT, 2018; FAO, 2019). In Europe, potatoes remain an essential crop, where per capita production is still the highest globally, although the most rapid expansion over the past few decades has occurred in Southern and Eastern Asia (FAO, 2020). In Sub-Saharan Africa (SSA) potato production has doubled since 1994, with 70% concentrated in Eastern Africa, particularly Kenya (FAO, 2020).

Potato farming in Kenya has increased in recent years due to increase in population and diversification of crops and is grown in about 192,000 hectares of land in Kenya annually (Kamau *et al.*, 2019; FAO, 2020). The major potato growing counties include; Bomet, Bungoma, Elgeyo Markwet, Kiambu, Meru, Nakuru, Narok, Nyandarua, Nyeri, Taita Taveta, Trans-Nzoia, Uasin Gishu and West Pokot (Sophie, 2018). The upper part of Embu County relies mainly on cash crops such as coffee and tea while the lower part mainly produces food crops such as maize, potatoes, beans, cow peas, bananas, sorghum, tomatoes, pawpaw, avocado and citrus fruits

(GoK, 2013). Potato is a major food crop in Embu County, supporting the livelihoods of rural farmers through income generation (FAO, 2020). However, potato yields in small-scale farms fall below potential mostly due to a potent combination of constraints including; low soil fertility, inadequate supply of certified seeds (Kinyua *et al*., 2001: Agyemang *et al*., 2020), use of low yielding varieties and infection by diseases (Olanya *et al*., 2012). Common diseases of potatoes in the region include late blight caused by *P. infestans* and bacterial wilt caused by *R. solanacearum* (Kaguongo *et al*., 2010; Elhalag *et al.*, 2020).

Bacterial vascular wilt is one of the most lethal diseases of potatoes, tomatoes, egg plants, pepper and tobacco (Hayward, 1994; Verma *et al.*, 2014; Abdurahman *et al*., 2017). The causative bacterium, *R. solanacearum* is widely distributed in tropical, sub-tropical and warm temperate climates and affects over 200 plant species from more than 50 families (Hayward, 1994; Paudel, Dobhal *et al*,. 2020). The wide range of host plants, long duration of inoculum survival in the soil and absence of a formal clean-seed system, makes the pathogen a major threat to potato production (Thomas-Sharma *et al.*, 2016). In Kenya, the infection was first reported in Embu in 1945 and has since spread to all potato growing areas, affecting over 70% of potato farms and causing yield losses of over 50% (Muthoni *et al*., 2012; Kamau *et al.*, 2019). The disease signs in tuber include slimy, sticky ooze tan- white to brownish beads (Zhang *et al.*, 2019). Infected plants wilts prematurely, tubers may rot within the soil or in storage (Elhalag *et al.*, 2020*).* The current production ranges between 8 to 15t/ha compared to the expected 30 to 40t/ha (Chamedjeu *et al*., 2018; Gitari *et al.*, 2018).

Common approaches in management of the disease are integrated combination of measures such as quarantines, use of pathogen-free propagating materials, phytosanitation, cultural practices of fallowing or rotation, chemical and biological control (Shimelis and Rob, 2012; Chamedjeu *et al*., 2018). The use of resistant cultivars (Meng, 2013), when available and proper rotation or fallow (Pradhanang *et al*., 2000; Charkowski *et al.*, 2020) have been used with limited success due to the pathogen's wide host range, broad distribution, great variability and ability to survive in soil and water.

2. MATERIALS AND METHODS

2.1 THE STUDY AREA

The study was conducted in Embu County which is located at longitude 0º31'52.03''N and latitude of 37º27'2.2''E. The rainfall pattern in Embu County is bi-modal with two distinct rainy seasons [Government of Kenya (GoK), 2013]. Long rains occur between March and June while the short rains fall between October and December. Rainfall quantity received varies with altitude averaging to about 1067.5 mm annually and ranging from 640mm in some areas to as high as 1,495 mm per annum (GoK, 2013). Temperatures range from a minimum of 12ºC in July to a maximum of 30ºC in March with a mean of 21ºC. The extensive altitudinal range of Embu County influences temperatures that range from 20ºC to 30 July is usually the coldest month with an average monthly temperature of 15°C while September is the warmest month with an average monthly

temperature rising to 27.1°C. Embu County has different agro ecological zones that range from high altitude zone (LH1) to upper midland, zone (UM4). Others zones are the LH0 being forest zone and UH0 which is basically catchment areas (Jaetzold, 2007).

The soils in Embu County are clayey with a clay content of the topsoil. The soils at higher altitude are rather acid, around pH 4.6. The northern part of the county relies mainly on cash crops such as coffee (*Coffea arabica* L.) and tea (*Camellia sinensis* L.), while the southern part mainly produces food crops such as maize (*Zea mays*), beans (*Phaeolus vulgaris* L.), fruits, and vegetables. The largest proportion of arable land in the county is used for agriculture, with farms averaging a little less than one hectare due to land fragmentation over the years (Piikki *et al.*, 2016). Specifically, the study was carried out in Embu East in Runyenjes at Kirimari, Nganduri, Gaturi South, Gaturi North, Kieni East and West villages where Irish potato is grown in small scale.

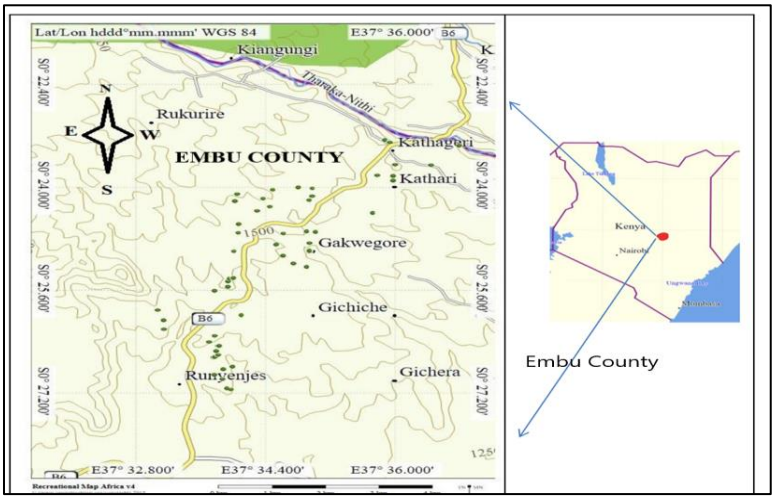

Figure 1: A map of Embu County showing sample collection area (Green spots)

2.2 SURVEY METHOD

An ecological survey method employing transect line was used for to study incidence of the potato bacteria wilt. Six potato fields in each different village in Runyenjes that measured 1/4 ha and above were purposively selected for this study. Potato farms selected were divided into four transects (50 m x 50 m) diagonally where study on disease incidence was then conducted. The geographical location and altitudes of each field visited was taken using a Geographical Positioning System. Three soil samples were randomly collected across each of the farms.

2.3 DATA COLLECTION

In the farms selected for survey, each of the farms was subdivided into four plots and survey for the bacteria wilt conducted in each of the plots. Within the plot, five rows of ten plants were selected at random and plants showing bacterial wilt symptoms were counted and recorded. Nine farms in each village and a total of 54 farms were surveyed. During the field assessment, the farms under the survey were inspected closely and the incidence recorded for each village as cluster. Disease incidence was calculated using the formula below.

$$\%\text{Disease incidence} = \frac{Number\ of\ diseased\ tubers}{Total\ tubers\ assesed}\ x\ 100$$

$$\%\textbf{Disease incidence}\ (soil) = \frac{\boldsymbol{Number\ of\ diseased\ soils}}{\boldsymbol{Total\ number\ of\ farms\ assesed\ plants}}\boldsymbol{x\ 100}$$

2.4 DATA ANALYSIS

One way ANOVA was conducted to determine the incidence of *R. solanacearum* in different villages in Runyenjes. Significance means were separated using least significance difference at α = .05 in SAS version 9.4.

3. RESULTS

3.1 THE INCIDENCE OF BACTERIAL WILT DISEASE PATHOGEN IN SOILS AND POTATO TUBERS

Incidences of potato bacteria wilt disease in different villages surveyed was significantly different (F (7, 37) = 3.3, *p-value* .0079) at α=.05. The overall mean for the incidence in potato was 32.2% with the highest mean incidence (50.42%) recorded at Kiangodu village (Table 1). The lowest mean incidence of 16.51% was recorded at Makutano village. Four villages Kangondu, Kathageri, Keremoi and Kiaragani recorded disease incidence mean above the overall mean (Table 1). The data was transformed (Arsin +5) for normality to meet expected assumption for analysis. Incidence of bacteria wilt pathogen differed significantly (F (7, 37) = 2.89, *p-value* .0165) at α=.05 from village to village. The highest mean (57.45%) of Bacteria wilt pathogen in soil sample was observed at Kangondu and the lowest (31.21%) at Kaithiga (Table 1).

Table 1: Incidence of bacteria wilt of potatoes in selected villages in Embu County

Village of Study	Ralstonia incidences in soil Samples	Mean potato bacteria wilt disease Incidences (%)
Kangondu	57.451 [ab]	50.422 [a]
Kathageri	57.444 [ab]	45.071[ab]
Keremoi_	43.245 [bc]	35.548[abc]
Kiaragani	33.646 [c]	33.841[abcd]
Gikuuri	36.051[c]	29.201[bcd]
Kaithiga	31.211 [c]	30.209 [bcd]
Kirangani	64.141 [a]	24.745 [cd]
Makutano	45.577 [abc]	16.509[d]
Mean	46.016	32.1995
LSD (p<0.05)	20.385	18.605
CV (%)	35.590	46.421

[a]Means followed by the same letters are not significantly different at α = 0.05

4. DISCUSSION

4.1 INCIDENCES OF BACTERIAL WILT PATHOGEN IN SOILS AND POTATO TUBERS

Incidences of bacteria wilt pathogen in soil and potato tubers from one location of sampling to the other differ significantly (p<0.05). The results of this study are supported by the study by Messiha (2006) and those of

Thera *et al.* (2010). Variation of incidences of *Ralstonia solanacearum* in soil and tubers assessed may be attributed to differences in soil environmental parameters across the farms. Variation of soil factors such as soil moisture, pH, organic matter and soil type influence concentration of soil microbes such as wilt pathogen (Sunaina *et al.*, 1989; Messiha, 2006; Karim *et al.*, 2018).

Soil moisture is a determiner of pathogenicity and dispersal of bacteria wilt pathogen (Sunaina *et al.*, 1989; Karim *et al.*, 2018). Soil moisture may affect pathogen's survival in a free state in the soil and pathogen's infection rate. Further, soil moisture may affect the rate at which disease develop upon infection and spread through soil (Shekhawat and Perombelon, 1991). Variation of soil organic matter across the farms and locations samples may also be the reason for varied results as been pointed out by Karim *et al.* (2018). According to Sunaina *et al.* (1989), potato root depth and root system may influence vertical distribution and infection by *Ralstonia solanacearum* which may explain the discrepancy observed in pathogen incidences between soils and tubers in same areas sample.

5. CONCLUSION AND RECOMMENDATIONS

Incidences of bacterial wilt pathogen in soil and tuber sampled from Runyenjes area of Embu County differed from farm to farm and location to location. In order to manage potato diseases caused by *Ralstonia solanacearum* in the study area, farmers should consider practice management strategies such as rotating potato farming with other non solanaceae crops.

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