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Bacterial Wilt, A Challenge in Solanaceous Crops Production At Kenyan Highlands and Lowlands

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***Abstract*— Ralstonia solanacearum, the causal agent of bacterial wilt disease, results in serious world-wide economic losses particularly in the tropics. Members of the family Solanaceae such as potato, tomato, chili and tobacco are the most affected. A survey was conducted in the period of short rains (October December) the year 2015, covering Kenyan highlands and lowland regions of Nyeri, Kiambu, Nyahururu, Kirinyaga, Murang'a, and Embu counties; the major production zones of potato, tomato and capsicum to determine the prevalence, effects and management measures in practice by farmers in control of this bacterium. The findings implicated high dependence of farmers to the solanaceous crops both for income and food (68%), and extensive presence of the bacteria in all the seven study counties. The survey indicated bacterial wilt as a big challenge in production of Solanaceae crops in central Kenya. Lack of elaborate disease management measures and poor seed systems (57%) were found to be the key contributors to the extensive spread, high prevalence (68.57%) and the high incidence (17.74%) of the disease. These findings indicated an urgent need for set up of affordable up to standards seed systems of Solanaceae crops family. This output will enable experimentation of the plant extracts and organic supplements as cheap measures in management of the bacterium leading to alleviation of bacterial wilt challenges in Kenyan highlands and lowlands.**

***Index Terms*— Bacterial wilt, challenge, Solanaceae crops, lowlands and highlands**

I. INTRODUCTION

Agriculture is the backbone of the Kenyan economy. However, the agricultural sector performs poorly with most crops yielding about 1/10th of their potential [1]. Drought and diseases have been the main cause of poor yields [1]. In Kenya, many farming areas are affected by bacterial wilt, this is a major constraint in production of *Solanaceae* crops.

The local seed selection system does not ensure clean planting materials. Practically farmers select seed which look healthy with naked eyes without any assurance of being free from bacterial wilt infection are one of the major causes of this challenge [2].

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Bacterial wilt disease was first reported in Asia and South America in late 1880's. Described the causal organism of bacterial wilt as *Ralstonia solanacearum* by then, scanty information existed on the incidence of this disease until in early 1950's when research on this disease was done Kelman, [3], [4]. *R. solanacearum* is highly heterogeneous species containing hundreds of distinct strains differing in natural host range, geographic distribution, biochemical and genetic characteristics; the bacterium is found worldwide [5], [6].

The host range of the bacterium is unusually broad with hundreds of plant species affected, [7], [8]. Worldwide, major hosts are: *Lycopersicon esculentum* (tomato), *Capsicum annum* (sweet pepper), *Solanum tuberosum* (potato), *Solanum melongena* (brinjal), *Nicotiana tabacum* (tobacco), *Arachis hypogaea* (groundnut), *Musa paradisiaca* (banana) and *Heliconia* spp (plantain) [9], [11]. It is also found on certain ornamentals and sunflower although not considered to be economically important to them [12].

Biovar 2 Race 1 of this pathogen has been suspected to occur in banana while biovar 2 Races 3 have been reported for the first time on geranium produced in greenhouses in Wisconsin grown from cuttings imported from Kenya [12]. A number of shrubs and trees (cassava, olive, eucalyptus) are also reported to be susceptible to the pathogen, including some ecotypes of *Arabidopsis thaliana*. Ginger is recognized to be one of the few monocots affected by *R. solanacearum* in tropical countries as reported in India, to be affected by biovar 3, [13].

The *R. solanacearum* can survive in soil or infected plant debris for prolonged periods [9], [14]. Many asymptomatic weeds harbor the bacteria in their roots and the disease can prevail in different soil types, [15]. According to some reports, potato brown rot in Europe is mainly spread through irrigation with contaminated water [16], [17]. This bacterium may also survive by colonizing the rhizospheres of non-host plants [18]. High temperatures (30-35 °C) promote occurrence of this disease, whereas soil temperatures below 20 °C are not suitable for the bacterial wilt disease [19] There are many infection routes of *R. solanacearum*; the common ones include latent infection on planting material, from soil, water, air, mechanical transmission and the actions of insects and nematodes [20]-[23]. The bacterium can spread in soil, in which it survives for varying periods of time and in irrigation (drainage) water [24]. *R. solanacearum* diagnostic techniques include bioassays, dilution plating on semi-selective media, fatty-acid analysis, immunofluorescence (IF), and PCR [12]. The genetic and pathogenic variations make the development of diagnostic and detection and control measures of *R. solanacearum* more difficult and complex [7].

Although it is difficult to estimate the total economic losses caused by bacterial wilt, it ranks as one of the most important plant diseases in entire world [23]. It is the second most damaging potato disease after late blight in tropical and sub-tropical areas. The pathogen attacks about 30 plant species both monocots and dicots, of which the most susceptible plants are potatoes, tomatoes, pepper, eggplant, and groundnut [3]. More than 80 countries around the world are affected by this disease, while the damages incurred exceed US $950 million each year [12].

Use of disease free potato seed tubers prevents the loss of both yield and quality (of about 30-100%) from moderate to serious infection, with a long term advantage of preventing soil contamination [3]. The survey was to establish the incidences and potential damage of *R. solanacearum* that cause bacterial wilt disease in central highlands and lowlands of Kenya. This will assist in the management of these serious world-wide economic food losses particularly in the tropics [24].

II. METHODOLOGY

A. Study site

The survey was conducted in Central highlands and lowlands of Kenya (Nakuru, Nyandarua, Nyeri, kirinyaga, Embu, Kiambu and Murang'a counties), the major production zones of potato, tomato and capsicum. These regions lies in the following bearings: 0^{0} .18'S 36^{0}.4'E, 0^{0} 18'S 37^{0}.27'E to 0^{0} 43's 36^{0}.4'E, 0^{0} 43'S 37^{0}. 27'S. At altitude of 850 m above sea level. Agro- ecological zones (AEZs) 1, 2 and 3 (high to medium potential), these regions receives Rainfall of about 650 to 3000 mm per annum and average temperatures range from 14 ^{0}C to 28 ^{0}C. The Soils are volcanic, loam and sandy soils, [25].

B. Survey and Sampling

Farm surveys for both lowland and highlands farmers' fields accompanied by questionnaires to farmers was carried out. This covered 10 (Potato, tomato and capsicum) farms in each of the seven study counties. Data was collected using personalized questionnaires with farmers. A total of 1400 Samples of diseased tomato and potato plants were collected, this was done by critically observing the bacterial wilt symptoms and through bacterial streaming test. At the Laboratory the diseased and wilted plant samples collected from the fields were washed under running tap water to remove sand and soil, the stem were surface sterilized with 70% alcohol, crushed and the bacteria cultured on CPG media and the semi-selective medium.

The assessment of the prevalence of Solanaceae family crops grown was done together with bacterial wilt prevalence and incidences estimated using the below formulas as adapted from [26].

$$\text{Prevalent Solanaceae crop} = \frac{Total\ numeber\ of\ fields\ with\ unique\ solani\ crop\ type}{Total\ fields\ assed} \times 100\%$$

$$\text{Disease prevalence} = \frac{Total\ field\ affected}{Total\ fields\ assed} \times 100\%$$

$$\text{Disease incidence} = \frac{Total\ assymptomatic\ plants}{Total\ plants\ per\ field} \times 100\%$$

The data collected was subjected to descriptive analysis using SPSS software, version 20 to obtain means, frequencies and percentages. The findings were presented in graphs charts and tables.

III. RESULTS

Majority of farmers interviewed had secondary level education (52%), 61.3 % from highlands and 38.7 % from lowlands. Few farmers (12%) had tertiary level education, 42.9 % (highlands) and 8.6 % (lowlands), (Fig 1).

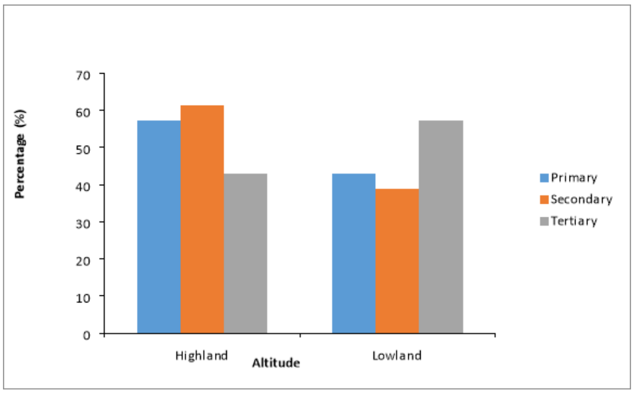

Figure 1. Education levels of respondent farmers

Among the respondents, majority (68%) were peasant farmers, 54.8% (highlands) and 45.2 % (lowlands). Of the respondents 12% had formal employment; of this 57.1% were from highlands and 42.9% from the lowlands (Fig. 2).

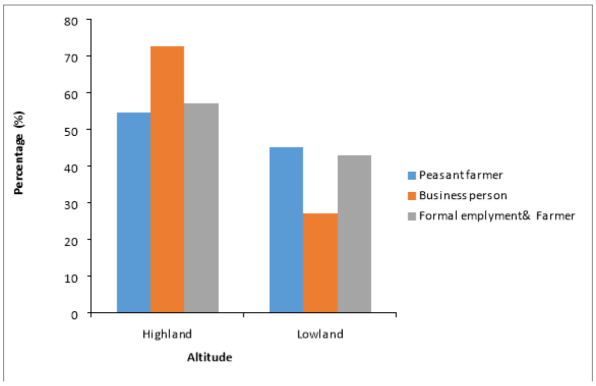

Figure 2. Farmers' income generation ventures

Majority (70%) of Solanaceae crops farms visited in the study counties had potato, with tomato and capsicum occupying small percentage of the farms at 24.29% and 5.71% respectively (Table 1).

Table 1. Solanaceae crop types grown

County	*Solanaceae crops* Tomato Prevalence	Rank	Capsicum Prevalence	Rank	Potato Prevalence	Rank
Embu	30%	2	0.00%	3	60.00%	1
Kiambu	30%	2	10.00 %	3	60.00%	1
Murang'a	10%	2	0.00%	3	80.00%	1
Nakuru	0.00%	2	0.00%	2	100.00 %	1
Nyandarua	0.00%	1	0.00%	2	100.00 %	1
Nyeri	40.00 %	2	10.00 %	3	50.00%	1
Kirinyaga	60.00 %	1	0.00%	3	40.00%	2
Overall prevalence	24.29 %	2	5.71%	3	70.00%	1

Traditional varieties were commonly grown (57%), with 30 % of the respondent farmers were using improved certified planting materials. Some few farms (13%) had a mixture of both traditional and certified planting materials in use. (Fig.3)

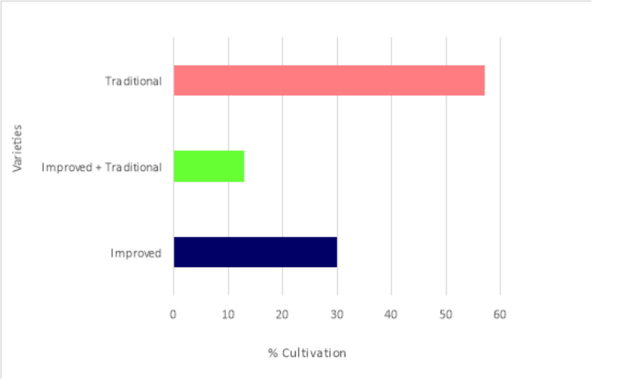

Figure 3. Solanaceae crops varieties grown

In the survey, farms (75 %) in highlands and 25 % in lowlands had plants with symptoms characteristic of bacterial wilt. (Fig.4)

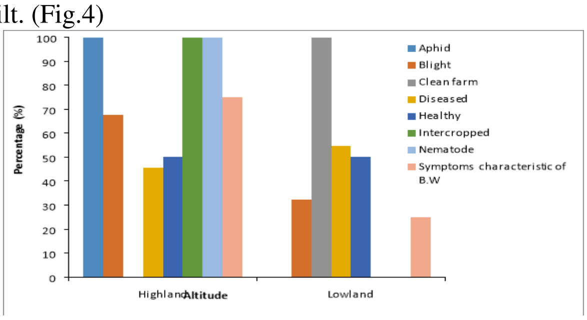

Figure 4. Conditions of Solanaceous crops at the fields

Among the counties the prevalence of bacterial wilt as from the observed asymptomatic plants (Field with plants typical symptoms of bacterial wilt) were very high in Embu (90%), Murang'a, Nakura, Nyahururu had a prevalence level of 80%, Kirinyaga 60%, Nyeri 50% and Kiambu county (40%) having the lowest bacterial wilt prevalence. Bacterial wilt incidences in the survey farms were high in Kirinyanga (26.00%), Murang'a (24.50%), Nakuru (19.00%) and Nyandarua (16.04%); they were low in Nyeri (10.60%) and Embu (13.05%) counties. (Table 2)

Table 2. Bacterial wilt prevalence and incidences

Bacterial Wilt				
County	Prevalence	Rank	Incidence	Rank
Embu	90.00%	1	13.05 %	6
Kiambu	40.00%	5	15.00 %	5
Murang'a	80.00%	2	24.50 %	2
Nakuru	80.00%	2	19.00 %	3
Nyandarua	80.00%	2	16.04 %	4
Nyeri	50.00%	4	10.60 %	7
Kirinyaga	60.00%	3	26.00 %	1
Average	68.57%	-	17.74 %	-

Farmer's had few strategies in management of bacterial wilt, with majority (61%) uprooting the diseased plants while 13 % carrying out crop rotation. 26 % of the respondent farmers had no measures in place for the control of the bacterium, (Fig.5).

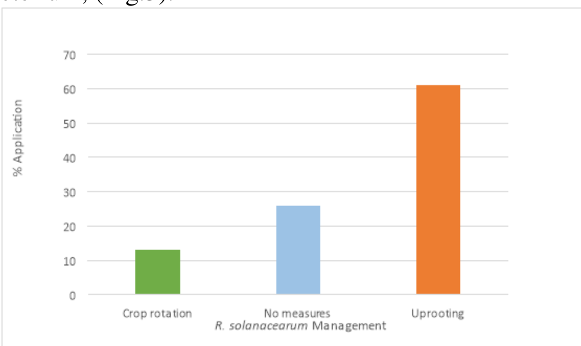

Figure 5. *R. solanacearum* Management Strategies

Good agronomic practices by farmers that are usually credited to integrated disease management were exhibited with, 63% of farmers using a mixture of both organic and inorganic fertilizers, 20% using inorganic fertilizers exclusively, 6% using organic fertilizers exclusively to supplement plant nutrients. 11% were yet to establish soil nutrient management measures for their fields, using nil fertilizer inputs in their farms.

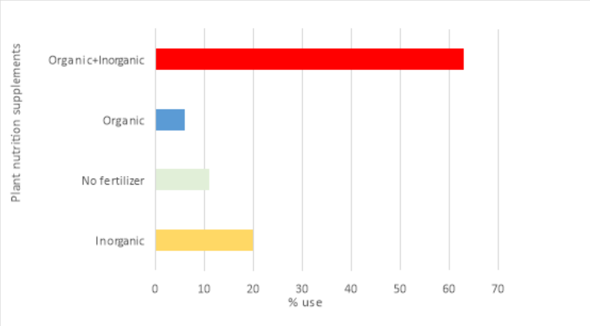

Figure 6. Plant nutrition management strategies

In the quick field diagnosis, the streaming of milky white masses of bacterial cells (ooze) confirmed the disease as bacterial wilt caused by *R. solanacearum.* The pure cultures obtained from isolates of the collected samples had colonies with pink colour at the centre and whitish margin (Plate 1).

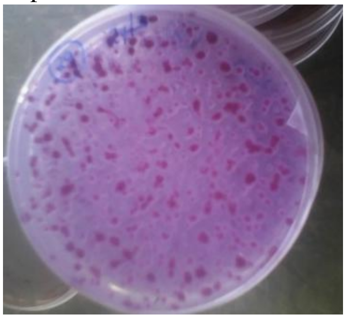

Plate 1. *R. solanacearum* on SMSA media

IV. DISCUSSION

Level of education is very important in influencing farmers' activities, many studies credit better plant, soil and environmental conversion to high level of education of the farmers. In the survey, majority of the farmers interviewed had basic education, these farmers were in capacity to easily practice the new crop protection measures including ensuring good field sanitation, controlling pests; the vectors of plant diseases and they could generally be more careful while carrying out field management practices, reducing injuries to crops [26]. Majority of the respondents were peasant farmers. In Kenya peasant farmers are in category of very poor individuals, they have less access to farm inputs such as fertilizers, pesticides, seeds and other planting materials. They have dependence on farms for income and food, a common scenario in Kenyan highlands and lowlands, and this is agreement to work done [28].

Potato is an important food crop in central Kenya areas, among the three Solanaceae crops potato was the most common. This crop in Kenya has had poor seed systems. This could have been the probable reason to why traditional varieties were found common. Poor seed systems contribute to the spread of the bacteria. The traditional varieties are preserved at farm level and sometimes borrowed from neighbours. Such seed preservation systems may not be to the required sanitation standards and the materials here are prone to contamination. These were similar to other findings [2]. Certified planting materials that are clean and free from diseases are necessary for management of the bacterial in farm. Five important potatao cultivars, Tigoni, Asamnte, Kenya Karibu, Kenya Sifaa and Dutch robjyn, found all of them susceptible to *R. solanacearum* attack, but Kenya sifa had a relatively high level of tolerance to the bacterium, it therefor implies such material that are clean and disease free (certified) can reduce losses due to this bacteria [29] Informal seed systems for solanaceous crops, as exhibited in this study been attributed to the spread of *R. solanacearum*, [30]. The low economic ability of the farmers in the study, together with poor potato seed systems make this approach in managing the disease by famers in central Kenya impossible [31],[32].

High prevalence and incidence of Bacterial wilt in potato growing area is a common scenario, the loses that results are too high and elaborate mitigation measures that will incorporate a complete overhaul of the production systems form new soil management, irrigation, and crop protection and provision of quality planting materials [33].

On soil nutrients management, use of nitrogen fertilizer inputs has always been credited to reduced effect of R. solanacearum, the high use of organic in addition to inorganic fertilizers in the study counties shows efforts in achieving this. Apart from the manures, other organic supplements and plant extracts have been reportedly been found effective in control of R. Solanacearum, their inclusion in the organic matter applied in the fields may be beneficial. The very key ones include: extracts from *Tarchonanthus camphorates* [34], *Acacia stuhlmannii* [35], *Lantana camara* L. [36] and *Azadirachta indica* [37]. Crop rotation though found to require long crop cycles can also an important measure when use in short cycles for crops such as cabbage. Decomposing cabbage releases volatiles that are effective against bacterial wilt [38], [39].

V. CONCLUSION

This survey indicated bacterial wilt as a challenge in production of capsicum, potato and tomato in Nakuru, Nyandarua, Nyeri, Kirinyaga, Embu, Kiambu and Murang'a counties. There was lack of elaborate measures in management of this disease. The poor seed systems were a major contributor to the extensive, spread, high prevalence and the high incidence of the disease observed.

VI. RECOMMENDATION

Low cost measures involving use of plant extracts and organic matter should be evaluated for management of bacterial wilt. Good farm practices such as sanitation and use of clean planting materials should be encouraged among farming communities. The government should devise measures that will enable set up of good seed systems for the crops of the Solanaceae family, to enable access to affordable access to high quality, disease free planting materials by farmers.

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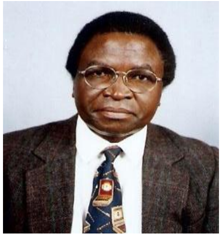

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