FARMERS KNOWLEDGE ON BACTERIAL WILT OF TOMATO IN LOITOKTOK AND MWEA, KENYA

L. K Shitiavai#, J.M Wanjohi and J. W Kimenju

Department of Plant Science and Crop Protection. College of Agriculture and Veterinary Sciences CAVS, University of Nairobi[1]. P.O. Box 29053-00625, Kangemi.

ABSTRACT

Bacterial wilt (*Ralstonia solanacearum*) is among the major diseases affecting tomato production. It causes the crop to wilt and completely die reducing the yield per acreage. The objective of this study was to be determine the status of bacterial wilt in Kajiado and Kirinyaga County. Out of 60 farmers identified, a sample of 30 farmers were chosen using a multistage sampling technique. Plant, water and soil samples were picked from their farms for isolation of *Ralstonia solanacearum* (Rs) bacteria in the plant pathology laboratory at Kenya Agricultural Livestock and Research Organization. Data was analyzed by finding frequencies using excel and SPSS software. Over 90% of the respondents from Kajiado and Kirinyaga counties reported to have experienced bacterial wilt of tomatoes in their fields. The disease was found to be important in Kirinyaga and moderately important in Kajiado counties. Crop rotation and fallowing were the main methods used to manage bacterial wilt. Many soil samples from Kirinyaga County turned positive for bacterial wilt, unlike those from Kajiado County. Farmers from both Kirinyaga and Kajiado counties should therefore be taught the most appropriate, effective and environmentally friendly methods of controlling bacterial wilt of tomatoes in their fields.

Keywords: Bacterial wilt, Kajiado, Kirinyaga, *Ralstonia solanacearum*.

INTRODUCTION

Among the most important diseases that pause a great challenge to tomato farmers is the bacterial wilt caused by *Ralstonia solanacearum* (Rs) on tomatoes (*Solanum lycopersicum* L.). Bacterial wilt of tomatoes causes losses of between 10 to 100% in both field and green house production systems. Incidence of bacterial wilt of tomatoes in the fields occurs in localized areas which serves as the primary foci from where it is spread (Jiang *et al*., 2017). Farmers do not have enough knowledge about the disease and the best way to manage it. They often unconsciously aid in dispersal of the bacterium through irrigation activities and routine performance of cultural practices and this has been reported in Embu, Kiambu, Nakuru, Nyandarua, Nyeri and Kirinyaga. *Rs* has a wider host range affecting sweet peppers, eggplant, brinjals, potatoes (Kago *et al*., 2017). Some races have also been reported on bananas. Management of bacterial wilt in tomatoes has been a great challenge to Kenyan farmers. Some recommended methods to suppress the disease in the field include the use of biological controls like *Trichoderma asperellum*, *Bacillus subtillis*, planting resistant cultivars and the use of clean seed (Konappa *et al*., 2018). The objective of this study was to determine the current occurrence of Bacterial wilt in Kajiado and Kirinyaga counties of Kenya, the counties were chosen because of their high production of tomatoes.

MATERIALS AND METHODS

Study area

The survey was carried out among tomato farmers in Kirinyaga and Kajiado counties of Kenya. Kajiado county lies between Latitude: -2° 00’ 0.00” S and Longitude: 36° 52’ 0.12” E. It receives a bimodal rainfall with two rainy seasons (Mutuma *et al*., 2020). The rainfall is however not uniform with some areas like Ngong receiving higher amounts precipitation of about 1,454 mm; Isinya 896 mm; Kajiado west areas like Magadi receives least rainfall of about 450 mm (Amwata *et al*., 2015). Temperatures in Kajiado range from 12.2 ^{0}C to 27.8 ^{0}C. The county has 4 Geological regions; Quaternary volcanics, Quaternary sediments, basement systems and Tertiary volcanics. Agriculture is conducted in the agricultural Zone IV and V of Kajiado County. Kirinyaga County (0.6591° S, 37.3827° E) (Nakhungu *et al*., 2019) receives an annual rainfall of between 900 to 1400 mm. Temperatures ranges from14 ^{0}C to 25 ^{0}C. The county has volcanic andosols that support growth of a wide range of crops. The altitude of

#Corresponding author: shetyavaikevin@gmail.com

the county is between 1480 meters and 6800 meters at the peak of the mountain.

Survey and sampling

Farmers were recruited using multistage sampling technique. An agricultural extension officer assisted in the selection of 60 farmers who had been growing tomatoes in the respective regions consistently for at least the last five years. A semi structured questionnaire was used to collect data from the farmers during the interview. Out of the 60 farms, 30 were randomly selected. Plant samples were selected from the farms to screen for presence of bacterial wilt, with at least 15 plants picked from every farm.

The sample size was calculated using the following

$$\frac{Z^2 \times P(1-P)}{e^2}$$

Where Z= Z score (1.96), P= Standard of deviation (0.0475), e = Margin of error (0.05)

The coordinates of the points from which samples were collected were documented. The samples were picked after careful screening to observe the symptoms. Bacterial streaming was done in the field to confirm the disease and both soil, water and plant samples were carried to Kenya Agricultural Livestock Research Organization (KALRO) pathology laboratories the same day of collection.

Isolation of *Ralstonia solanacearum* (Rs)

The bacteria was extracted on 2,3,5-triphenyl-2H-tetrazolium chloride ($C_{19}H_{15}ClN_4$) media. Tetrazolium chloride medium was prepared using Casamino acid 1g, Peptone 10 g, Glucose 5g, agar 17 g, and dissolved in pure distilled sterile water 1000 ml. Infected tomato plant samples were chopped into 1cm pieces, surface sterilized in 1.5% sodium chloride (NaOCl) and rinsed three times in dH_2Owater (Razia *et al*., 2021). The samples were blotted on sterilized filter papers and placed on the tetrazolium chloride media and the plates incubated for 48 hours. The colonies appeared dark red in color.

Approximately 1g of soil from each field was suspended in 10 ml of pure dH_2O and then shaken vigorously. Approximately 1 ml from the stock solution was added to 9 ml in the next universal bottle and serial diluted to 10^7.

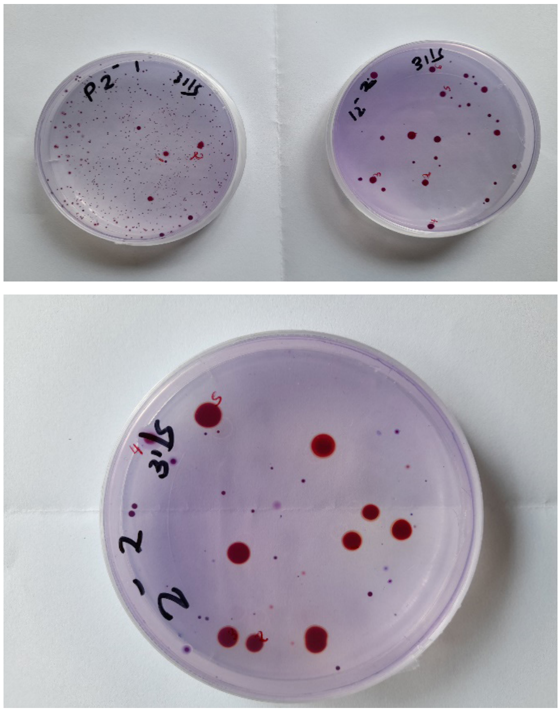

Figure 1. Isolates of Rs in Tetrazolium media

Dilutions 10^3, 10^5 and 10^7 were plated using pour plate method on Tetrazolium chloride media (Pontes *et al*., 2017) and incubated at 28 °C for 48 hours.

Confirmation of the pathogen

Rs inoculum was prepared by washing the plates with distilled water to suspend the bacteria. Colonies of bacteria were scrapped with a microscope slide to dislodge all the colonies. The concentration of the stock solution was determined by serial diluting it to 10^7, plating the samples for 48 hours using pour plate method and counting the colonies (Singh *et al*., 2018). To get a concentration of 10^7, adjustments were done by dividing the number of colonies forming units gotten by dilutions 10^7. Four tomato varieties were planted in a screen house, watered daily and were inoculated with the *Rs*. Inoculation was done by trimming roots and adding 15 ml of inoculum per pot at the base of the tomato. Symptoms were observed for 21 days and symptomatic plants counted.

Data analysis

Data were analyzed using excel and the separation of means was done by analysis of variance while computation of frequencies of the responses was done in SPSS. Prevalence and incidences of bacterial wilt was done using the following formulae.

Bacterial wilt prevalence =

$$\frac{Total\ fields\ affected}{Total\ fields\ assessed} \times 100$$

Bacterial wilt incidence =

$$\frac{Total\ symptomatic\ plants}{Total\ plants\ in\ the\ field} \times 100$$

Severity of the disease was calculated as the ration of infected fields out of 100.

RESULTS

From the study, the proportion of bacterial blight of tomatoes was the same for both Kirinyaga and Kajiado counties (Figure 2). This was the most prevalent tomato disease affecting farmers in the two counties. Blossom end rot also had a prevalence of about 80% and was not significantly different between the two counties. Bacterial wilt was the most prevalent disease affecting tomatoes in Kirinyaga and Kajiado counties. About 10%of of spotted wilt virus of tomatoes was the least and observed only in Kajiado County.

A good proportion of the respondents reported to have observed bacterial wilt of tomatoes in their farms in both Kajiado and Kirinyaga counties. Less than 10 percent of the respondents reported not to have seen bacterial wilt in their tomatoes (Figure 3).

At least 75 percent of the respondents in Kirinyaga reported that bacterial wilt of tomatoes was a very important disease in the county. Forty six percent in Kajiado and 14 percent in Kirinyaga reported that bacterial wilt was of moderate importance. However, 53% and 10% in Kajiado and Kirinyaga Counties, respectively thought that bacterial wilt of tomatoes was not a very important disease.

Most farmers had reported to have observed bacterial wilt in their field in the last 2 years. However, there those farmers who had seen the disease for the last six years in their tomato farms especially in Kirinyaga County. It's only in Kirinyaga County where bacterial wilt of tomato had been prevalent for over 10 years (Figure 5).

Tomato diseases were among the major constraints

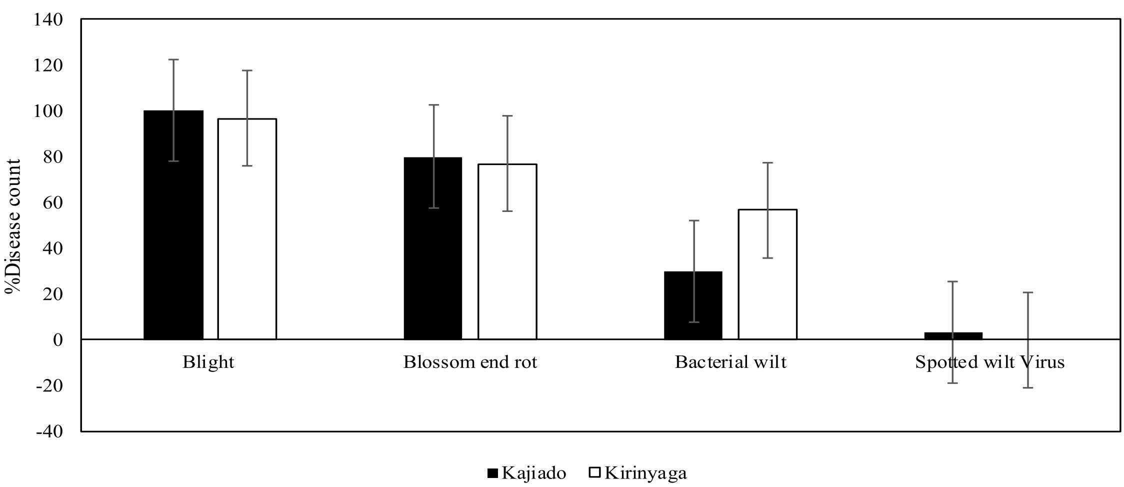

Figure 2: Disease response in Kajiado and Kirinyaga County

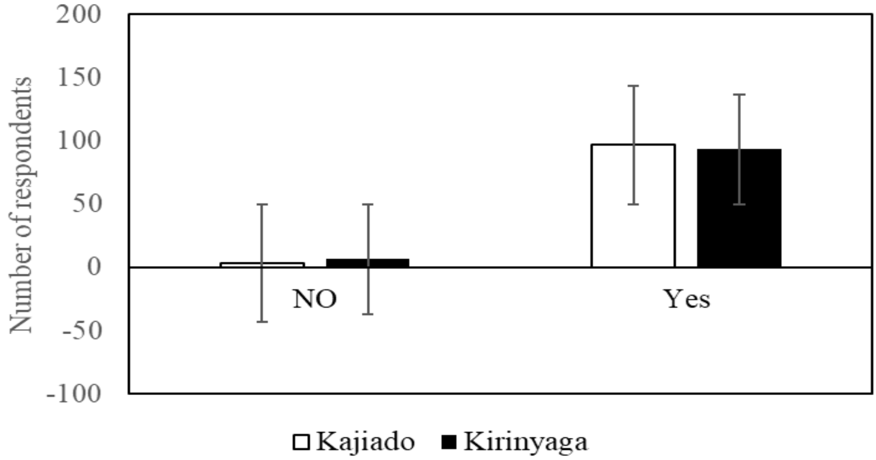

Figure 3: Percentage response of farmers who observed bacterial wilt of tomatoes in their fields in Kajiado and Kirinyaga counties

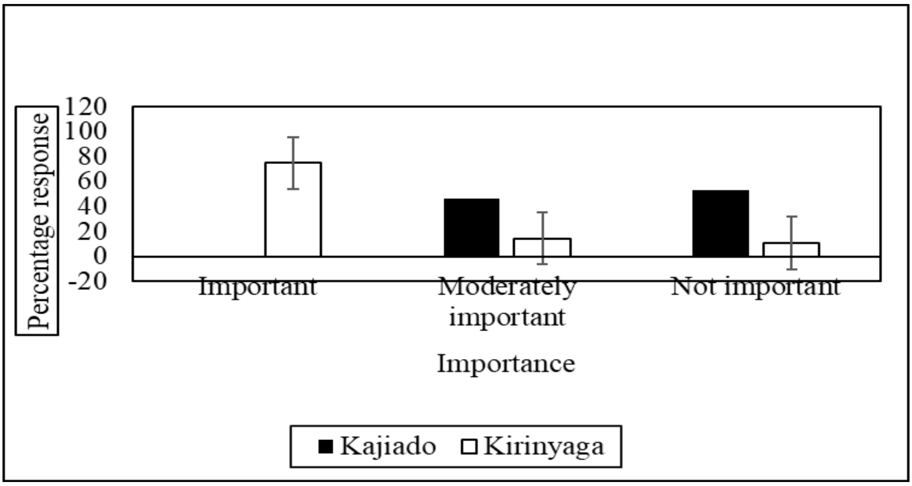

Figure 4: Importance of Bacterial wilt of tomatoes in Kajiado and Kirinyaga County.

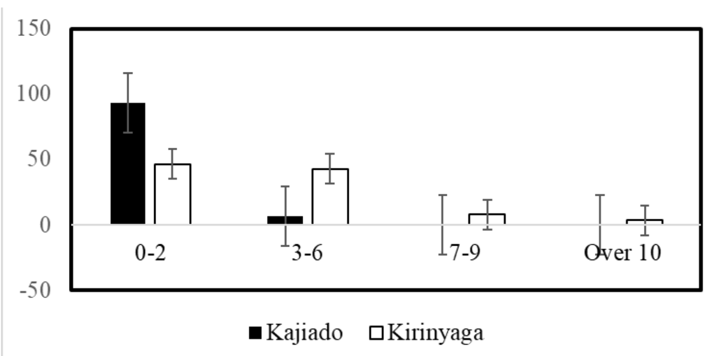

Figure 5: Percentage response of the number of years farmers have observed bacterial wilt of tomatoes in farmer's fields

affecting tomato farmers in Kirinyaga and Kajiado County by 80% and 83% respectively. Other major production constraints reported were labor, market, fertility and wild animals (Table I).

Farmers in Kirinyaga County controlled bacterial wilt of tomatoes mainly by crop rotation and rouging. With 50 percent preferring to remove and burn infected plants from the field. A few of the famers, 10% leave their fields fallow for some time (Table II).

TABLE I- PRODUCTION CONSTRAINTS IN TOMATO PRODUCTION IN KAJIADO AND KIRINYAGA COUNTIES IN KENYA.

Production constraints		County Kajiado	Kirinyaga	Total
Pests	Count	22	29	51
	% Within County	73.3%	96.7%	
Disease	Count	24	25	49
	% Within County	80.0%	83.3%	
Labour	Count	4	0	4
	% Within County	13.3%	0.0%	
Market prices	Count	6	1	7
	% Within County	20.0%	3.3%	
Fertility	Count	5	0	5
	% Within County	16.7%	0.0%	
Wild animals'	Count	4	0	4
	% Within County	13.3%	0.0%	
Total	Count	30	30	60

Percentages and totals are based on respondents.

a. Dichotomy group tabulated at value 1

TABLE II- FARMERS MANAGEMENT OF BACTERIAL WILT

Management methods	Frequency	%
Crop Rotation	21	36.2
Rouging	30	51.7
Spraying Herbicides	1	1.70
Fallowing	8	10.4
Total	60	100.0

The soils samples collected from Kirinyaga County recorded presence of Rs Out of the 30 samples collected, 21 had Rs colonies. However, 9 farms whose soil was sampled had no bacterial colonies (Table III).

TABLE III- MWEA SOIL SAMPLE ANALYSIS

Sample No	10^-2	10^-3	10^-4	Mean
2	0	0	0	0 a
6	0	0	0	0 a
7	0	0	0	0 a
12	0	0	0	0 a
13	0	0	0	0 a
16	0	0	0	0 a
26	0	0	0	0 a
29	0	0	0	0 a
30	0	0	0	0 a
5	967	567	833	789 ab
19	1400	833	500	911 ab
17	1567	1133	1933	1544.3 ab
27	3367	1767	1233	2122.3 abc
25	4933	1767	2867	3189 abc
20	5033	2733	1867	3211 abc
3	1867	1267	6933	3355.7 abc
14	4433	3233	2833	3499.7 abc
22	4733	4200	1633	3522 abc
24	6200	2600	2033	3611 abc
4	1900	3967	5233	3700 abc
28	7067	3700	1433	4066.7 abc
9	6767	3200	3500	4489 abc
15	10100	2467	1933	4833.3 abc
23	9667	2833	4100	5533.3 abc
10	8500	2500	5667	5555.7 abc
18	10533	5400	3967	6633.3 abc
21	13833	2800	4500	7044.3 bc
11	15933	4700	5433	8688.7 c
8	35867	5533	9167	16855.7 d
1	29400	9333	12300	17011 d
Mean				3672.2
LSD				3436.8
CV%				100.6
P value				<.001

CFU dilutions 10^-2, 10^-3 and 10^-4 for the samples 5, 19 and 27 showed significant differences. The number of colonies reduced as the dilution factor increased as shown with sample 19 and 27. Sample 27 had the highest number of colonies as compared to sample 5 and 19 as shown in figure 6.

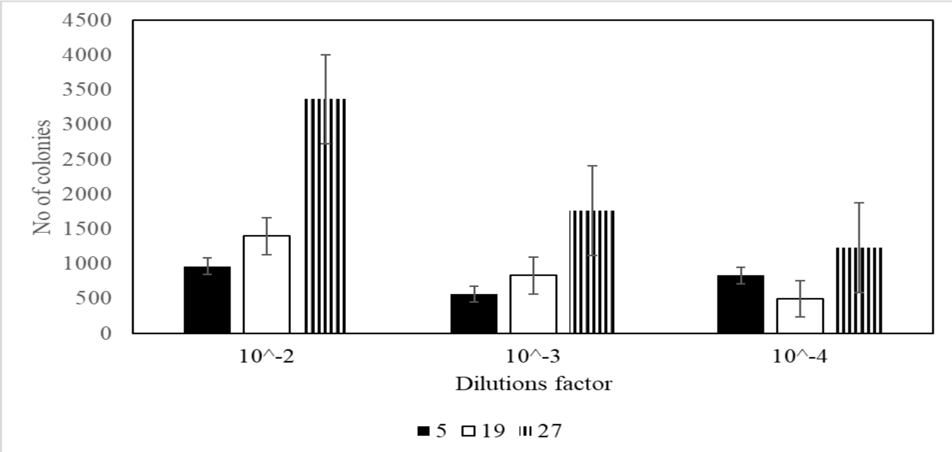

Figure 6: CFU dilutions 10^-2, 10^-3 and 10^-4 for the samples 5, 19 and 27

TABLE IV- LOITOKTOK SOIL SAMPLE ANALYSIS

	Dilution			
Sample	10^-2	10^-3	10^-4	Mean
1	0.0	0.0	0.0	0 a
2	0.0	0.0	0.0	0 a
3	0.0	0.0	0.0	0 a
4	0.0	0.0	0.0	0 a
5	0.0	0.0	0.0	0 a
6	0.0	0.0	0.0	0 a
7	0.0	0.0	0.0	0 a
8	0.0	0.0	0.0	0 a
9	0.0	0.0	0.0	0 a
10	0.0	0.0	0.0	0 a
11	0.0	0.0	0.0	0 a
12	0.0	0.0	0.0	0 a
13	0.0	0.0	0.0	0 a
14	0.0	0.0	0.0	0 a
15	0.0	0.0	0.0	0 a
16	0.0	0.0	0.0	0 a
17	0.0	0.0	0.0	0 a
18	0.0	0.0	0.0	0 a
19	0.0	0.0	0.0	0 a
20	0.0	0.0	0.0	0 a
21	0.0	0.0	0.0	0 a
22	60.0	116.7	76.7	84.4 ab
23	160.0	60.0	40.0	86.6 ab
24	180.0	103.3	73.3	118.8 abc
25	250.0	93.3	73.3	138.8 bcd
26	280.0	160.0	226.7	222.23 cde
27	426.7	113.3	143.3	227.7 cde
28	283.3	273.3	146.7	234.4 cde
29	113.3	463.3	210.0	262.2 de
30	363.3	250.0	240.0	284.4 e
				55.3
				69.56
				135.2
				<.001

Loitoktok samples (9) showed colonies of *Ralstonia solanacearum* while 21 samples had no inoculum of bacterial wilt (Table IV).

DISCUSSION

Bacterial wilt of tomato is a serious disease in the major tomato growing regions of Kenya such as Kirinyaga and Kajiado Counties. A survey conducted by Kago et al. (2016) concluded that bacterial wilt was a major constraint to production of tomatoes in Kenya. It affects both large-scale and small-scale tomato farmers, those growing tomatoes in the open field and those growing in the high tunnels. Aloyce. (2019) did research on the severity and incidence of bacterial wilt of tomatoes and found that the disease was much severe in greenhouse than in the open field (Aloyce *et al*., 2019). Most farmers are aware of the disease especially the symptoms but do not know the biology of the pathogen, hence is widely spread in the regions (Tafesse *et al*., 2018). Others implemented management strategies that are not effective due to the limited information they have about the disease. The farmers practice production strategies that aid in the spread of bacterial wilt in one field or even between fields such as irrigation which they use without sterilizing equipment's. In addition, use of seeds and seedlings from non-certified sources were reported among the farmers as contributing to ease of spread of the bacteria. According to Aloyce et al. (2017), irrigation water aids to the spread of bacterial wilt from one individual farm to the other. Farmers often grow susceptible varieties without their knowledge which puts them at risk of losing a good amount of their final produce.

Rs is spread in both Kirinyaga and Kajiado counties of Kenya and a good number of the farms where samples were collected produced *R. solanacearum* colony forming units. In a study conducted by Kago. (2016), bacterial wilt of tomatoes is widely extensive in about 60% of the farms. Over 90% of the farmers who were interviewed in both Kirinyaga and Kajiado counties reported that they had observed bacterial wilt in their fields. This study revealed that proportion of bacterial wilt of tomatoes was higher in Kirinyaga than Kajiado County. The differences might be due to a wide range of factors like availability of clean tomato seeds and how the farmers conduct their agronomic activities. Tomato farmers in Kirinyaga county gets their water from Rivers like Nyamindi while those in Kajiado gets water from underground boreholes (Nakhungu *et al*., 2019). Water from underground is mostly clean unlike the moving river that collects inoculum from different fields as they meander on land. Other tomato diseases reported included blight, blossom end rot and spotted wilt of tomato. Kajiado County especially Loitoktok experienced less infections of bacterial wilt disease because of the number of farming years of tomato. Respondents in Kirinyaga traced observation of bacterial wilt of tomatoes in their fields for over 10 years while those in Kirinyaga observed for a period of between 0-2 years (Nakhungu *et al*., 2019). Only a few of the farmers in Kajiado had reported the disease in their field for the last 3-6 years.

Most farmers in Kirinyaga County saw bacterial wilt of tomato as a very important disease. About 14% reported that disease was moderately important while 10% did not consider bacterial wilt of tomato to be important disease. The reasons why a huge percentage of the farmers felt that bacterial wilt was a very important disease is because they practice tomato farming for commercial purpose. Presence of bacterial wilt makes them experience yield losses of about 88 % which is so significant (Mamphogoro *et al.,* 2020). The results were contrary to those in Kajiado who mostly scored bacterial wilt to be of moderate importance and no importance at all. The farmers in Kajiado experienced slightly lower cases of bacterial wilt and therefore the losses incurred were less causing no significant losses.

Tomato diseases affected farmers so much that over 80 percent of the respondents put it among the major constraint in tomato cultivation. The soils from the major tomato growing regions had *R. solanacearum* causing crop cultivation to be difficult even when management strategies are implemented. There were however a few fields that were still clean reporting no bacterial colonies. This was true for both Kajiado and Kirinyaga counties. Most of the samples from Kirinyaga however had *Rs* compared to those from Kajiado County. The amount of *Rs* on the soil determines the incidence of bacterial wilt in tomato field (Lee *et al*., 2020).

CONCLUSION AND RECOMMENDATIONS

It was found that bacterial wilt of tomato was a major constraint of tomato production in Kirinyaga and Kajiado counties affecting nearly all the farmers. Most of the fields in Kirinyaga were contaminated by *Rs* inoculum with only a few farms being clean which was attributed to the main method of irrigation water which is the river. However, Kajiado farmers had clean fields with no inoculum incidences which was also attributed to their source of water being underground boreholes. It was also found that bacterial wilt of tomato had been in Kirinyaga County for a longer period of time above 10 years unlike in Kajiado County. Farmers in Kirinyaga and Kajiado Counties ought to be taught the best integrated management measures to help curb the spread of bacterial wilt inoculum from contaminated fields to clean fields. They also need to know the best methods to manage bacterial wilt to reduce on the resultant losses on the tomato crop.

REFERENCES

Aloyce, A., Ndakidemi, P. A., and Mbega, E. R. (2017). Identification and management challenges associated with *Ralstonia solanacearum* (Smith), causal agent of bacterial wilt disease of tomato in sub-Saharan Africa. *Pakistan Journal of Biological Sciences*, *20*(11), 530-542.

Amwata, D. A., Nyariki, D. M., and Musimba, N. R. (2015). Factors influencing pastoral and Agropastoral household vulnerability to food insecurity in the Drylands of Kenya: A case study of Kajiado and Makueni counties. *Journal of International Development*, *28*(5), 771-787.

Aslam, M. N., Mukhtar, T., Hussain, M. A., and Raheel, M. (2017). Assessment of resistance to bacterial wilt incited by *Ralstonia solanacearum* in tomato germplasm. *Journal of Plant Diseases and Protection*, *124*(6), 585-590.

Guan, Z., Biswas, T., and Wu, F. (2018). The U.S. tomato industry: An overview of production and trade. *EDIS*, *2018*(2).

Jiang, G., Wei, Z., Xu, J., Chen, H., Zhang, Y., She, X., Macho, A. P., Ding, W., and Liao, B. (2017). Bacterial wilt in China: History, current status, and future perspectives. *Frontiers in Plant Science*, *8*.

Kago, E., Kinyua, Z., Maingi, J., and Okemo, P. (2017). Diversity of *Ralstonia solanacearum* strains in solanaceous crops production regions of central Kenya. *Journal of Experimental Agriculture International*, *16*(1), 1-12.

Konappa, N., Krishnamurthy, S., Siddaiah, C. N., Ramachandrappa, N. S., and Chowdappa, S. (2018). Evaluation of biological efficacy of Trichoderma asperellum against tomato bacterial wilt caused by *Ralstonia solanacearum. Egyptian Journal of Biological Pest Control*, *28*(1).

Lee, S., Kong, H. G., Song, G. C., and Ryu, C. (2020). Disruption of Firmicutes and Actinobacteria abundance in tomato rhizosphere causes the incidence of bacterial wilt disease. *The ISME Journal*, *15*(1), 330-347.

Mutuma, S. N., Ngare, G. W., and Okemwa, P. (2020). Gender-related factors that influence women and men's participation in small-scale greenhouse farming in the Peri-urban area of Ongata Rongai, Kenya. *The International Journal of Humanities* and *Social Studies*, *8*(7).

Mamphogoro, T., Babalola, O., and Aiyegoro, O. (2020). Sustainable management strategies for bacterial wilt of sweet peppers (*Capsicum annuum*) and other solanaceous crops. *Journal of Applied Microbiology*, *129*(3), 496-508.

Nakhungu, M. V., Margaret, N. K., Deborah, A. A., and Peterson, N. W. (2019). Types and classification of pesticides used on tomatoes grown in Mwea irrigation scheme, Kirinyaga County, Kenya. *European Journal of Nutrition* and *Food Safety*, 83-97.

Nakhungu, M. V., Margaret, N. K., Deborah, A. A., and Peterson, N. W. (2019). Types and classification of pesticides used on tomatoes grown in Mwea irrigation scheme, Kirinyaga County, Kenya. *European Journal of Nutrition* and *Food Safety*, 83-97.

Ochilo, W., Nyamasyo, G., Kilalo, D., Otieno, W., Otipa, M., Chege, F., Karanja, T., and Lingeera, E. (2019). Characteristics and production constraints of smallholder tomato production in Kenya. *Scientific African*, *2*, e00014.

Pontes, N. C., Fujinawa, M. F., and Oliveira, J. R. (2017). Selective media for detection and quantification of Brazilian *Ralstonia solanacearum* isolates in soil. *Horticultura Brasileira*, *35*(1), 41-47.

Razia, S., Chowdhury, M. S., Aminuzzaman, F. M., Sultana, N., and Islam, M. (2021). Morphological, pathological, biochemical and molecular characterization of <i>*Ralstonia solanacearum*</i> Isolates in Bangladesh. *American Journal of Molecular Biology*, *11*(04), 142-164.

Sibomana, M. S., Workneh, T. S., and Audain, K. (2016). A review of postharvest handling and losses in the fresh tomato supply chain: A focus on sub-Saharan Africa. *Food Security*, *8*(2), 389-404.

Singh, N., Phukan, T., Sharma, P. L., Kabyashree, K., Barman, A., Kumar, R., Sonti, R. V., Genin, S., and Ray, S. K. (2018). An innovative root inoculation method to study *Ralstonia solanacearum* pathogenicity in tomato seedlings. *Phytopathology®*, *108*(4), 436-442.

Tafesse, S., Damtew, E., Van Mierlo, B., Lie, R., Lemaga, B., Sharma, K., Leeuwis, C., and Struik, P. (2018). Farmers' knowledge and practices of potato disease management in Ethiopia. *NJAS - Wageningen Journal of Life Sciences*, *86-87*, 25-38.