Incidence and Severity of *Solanum lycopersicum*Bacterial leaf spot Caused by Xanthomonad species in Farms in Wanguru, Mwea, Kirinyaga County, Kenya

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Abstract- Demand for tomato has increased tremendously but its production has been bedeviled by phytopathogens such as bacteria leaf spot. Studies have reported cases of bacteria leaf spot associated with tomato losses in many tomato production regions globally. However, despite persistent of tomato diseases in different agroecological regions in Kenya, there is scanty information on incidences and severity of individual diseases. This study was done to determine the incidence and severity of bacteria leaf spot of tomato in Wanguru in Mwea, Kirinyaga county in Kenya between February and April 2019. A total of ten tomato farms were selected randomly for the surveyed of incidence and severity bacteria leaf spot.From these ten farms, a total of 3000 tomato leaves in 100 tomato plants were assessed. Severity was scored by rating on a scale of 0 – 5. Data collected was subjected to analysis of variance using SAS software version 9.3 and significant means separated using least significance difference (LSD). Results showed that bacterial leaf spot incidence and severity was significant (p<0.05). Bacteria leaf blight was observed in all farms but at lower rates. However, the incidence was below 15% with farm 7 recording mean of 13%. The lowest incidence was observed in farm 3 and 5 recording 8.333%. Severity observed in all the farms was below 35% with farm 7 recording severity mean of 33.333% while farm 5 recorded lowest severity mean of 16.000%. This study therefore reports the incidences and severity of bacteria leaf spot caused by Xanthomonads species complex though at lower rates. The study should be extended to other tomato production areas in Mwea.

Indexed Terms: incidence, Severity, Tomato_Leaf_spot, Wanguru, Mwea, Kenya

I. INTRODUCTION

Tomato fruit is among the world's most consumed vegetable and an important cash and industrial crop that is produced worldwide (Olanrewaju *et al*., 2017). Tomato is rich in; carotene, essential amino acids, sugars, dietary fiber,vitamins A, B, C, iron, phosphorous, protein, edible oil and lycopene (Silva *et al.,* 2019). Demand for tomato continues to grow due to high rising population (Akbar *et al.,* 2018). Globally, China is the largest producer of tomatoes followed by the United States and India. Nonetheless, Mexico is the world`s largest tomato exporter (FAO, 2017; Singh *et al.,* 2017). In Africa where Egypt leads in tomato production followed by Nigeria (Ebimieowei and Ebideseghabofa, 2013), Kenya is ranked 6th with 397,007 tons of total production (FAO, 2012). Tomato farming is a source for household income and provides employment opportunities both in the rural and in urban. In Kenya, tomato production accounts for 14 % of the total vegetable produce and 6.72 % of the total horticultural crops (Gok, 2012). Between 2012 and 2014, the total national production was 400,204 MT valued at Kenya shillings 11.8 billion. Tomato is among the leading important crop grown for income generation by most farmers at Mwea in Kirinyaga county (Mwangi *et al*., 2015). Based on national production, Kirinyaga county ranked position 4 producing 48,560 MT of tomato after Bungoma (50,399 MT) and Kajiado (47368 MT) in 2014 (GoK, 2014). Major tomato cultivars grown in Kirinyaga include; Safari, Kilele F1, Prosta F1 and Rio- Grande (Mwangi *et al*., 2015). Tomato has global and national importance, but its production is challenged with a myriad of constrains (GoK, 2014). Tomato yield in Kenya is significantly low due to effects of insect pests and phytopathogen factors; fungi, viruses and bacteria (Mengesha, 2017).

Bacterial diseases of tomatoes include; Bacterial leaf spot caused by *Xanthomonas campestris*. Bacterial leaf spot is highly destructive, causes 10–50% yield loss both in greenhouses and in field conditions but may rise to 80% in some cases (Singh *et al.,* 2017). Another Bacterial disease is tomato bacterial wilt caused by *Ralstonia solanacearum;* a soil-borne tomato plant pathogen (Huang *et al.,* 2013). Lastly, tomato wilt and canker are caused by bacteria *Clavibactermichiganensis*.*Clavibactermichiganensis* infection systemically causes wilting and canker on the stem, while blister-like spots are developed in locally infected leaves causing substantial economic loss in tomato productionworldwide. *Clavibactermichiganensis* viru lence factor causes local and systemic infection in tomato (Chalupowicz*et al.,* (2017).

Bacterial spot disease; a complex of Xanthomonas species remains a serious concern in tomato production (Horvath *et al.,* 2012) occurring in warm and humid climates (Jones *et al.,* 2014). Years over, commercial industry has been unable to control it despite use of extensive chemical, genetic, and cultural methods (Horvath, *et al.,* 2012; Griffin *et al*., 2017). Bacterial spot was first reported on tomato in South Africa in 1914, and named *Bacterium vesicatorium* (Doidge, 1920; Potnis *et al.,* 2015) and later reclassified severally to *Pseudomonas vesicatoria*, *Phytomonas,vesicatoria* and *Xanthomon as campestris* pv. *vesicatoria* (*Xcv*) (Dye *et al*., 1964; Jones *et al*.,1998; Jones *et al*., 2005; Timilsina *et al*., 2015; Potnis *et al.,* 2015). Currently, *Xanthomonas* spp. are widely spread in different geographical regions (Horvath *et al.,* 2012; Kebede *et al*.,2014)with *X. euvesicatoria* and *X. vesic atoria* being common. Different species of bacterial spot-causing xanthomonads have been isolated from tomato-growing regions. Countries with reported cases of xanthomonas include; Ukrane(Kolomietsa *et al.,* 2017), Mexico (Bouzar *et al*., 1996), India (Hamza *et al*., 2012); Nigeria (Jibrin *et al*., 2014), Ethiopia (Kebede *et al*.,2014) and in Bulgaria (Stoyanova *et al*., 2014), Tanzania (Shenge*et al.,* 2010; Mbega*et al.,* 2012). World-wide, Xanthomonas spp isolated from tomatocrops include; *X. euvesicatoria*, *X. vesicatoria* and *X. perforans* and *Xanthomonas gardneri*has (Horvath *et al*.,2012; Kebede *et al*., 2014).

The host range of bacterial spot xanthomonads includes Solanaceae family, mainly tomato (*Solanum lycopersicum*), cherry tomato (*Solanum lycopersicum* var. *cerasiforme*), currant tomato (*L. pimpinellifolium*), pepper (*Capsicum annuum*), chilli peppers (*Capsicum frutescens*) among others (Baker *et al*., 2014). *Xanthomonas* spp pathogen gains access into the leaf via stomata and wounds created by wind-blown soil, insect punctures, or mechanical means (Cerkauskas, 2005; Potnis *et al*., 2015). Upon entry into the plant, pathogen grows in the substomatal chamber and multiply in intercellular spaces.

Bacterial spot of tomato is characterized by necrotic lesions on the leaves, stems, petals and flowers, and fruit (Abbasi *et al.,* 2002;Potnis *et al.,* 2015). Foliar lesions are dark, circular, water-soaked, and usually smaller than 3 mm in diameter (Cerkauskas, 2005). Lesions have greasy appearance on upper leaf surface and later become brown-black and angular in shape (Cerkauskas, 2005). During wet conditions, numerous lesions occur which coalesce giving plants a blighted appearance. Affected leaves turn yellow and may drop off (Cerkauskas, 2005). In fruits, lesions begin as small, raised, black specks surrounded by a water-soaked border, enlarging to become brown, slightly sunken, scabby spots, sometimes surrounded by a halo. Nonetheless, these spots are not deep and do not usually cause fruit rot (Cerkauskas, 2005). Leaf spot pathogens are spread by wind and water with ability to survive in crop residues, weeds and volunteer plants (Roach *et al*, 2017). Regions with high temperatures, high relative humidity, high plant density and overhead irrigation are ideal environment for development and spread of leaf spot disease (Potnis *et al.,* 2015). Leaf spot bacteria wilt is an economically significant disease in tomato plantations. However, its occurrence in tomato farms in Kirinyaga county; a major tomato production hub in Kenya is scarcely documented.

II. MATERIALS AND METHODS

Study Area

Wanguru area is located within Mwea irrigation scheme in Kirinyaga county, Southern outskirts of Mt. Kenya and approximately 100 Kilometers

North East of Nairobi (Serede *et al.,* 2015). The area lies between latitudes 0° 37'S and 0° 45'S and between longitudes 37° 14'E and 37° 26'E and between 1,100 m and 1,200 m above mean sea level. Area under scheme receives an average annual rainfall of 940 mm. The long and short rains occur from April to May and October to November respectively.

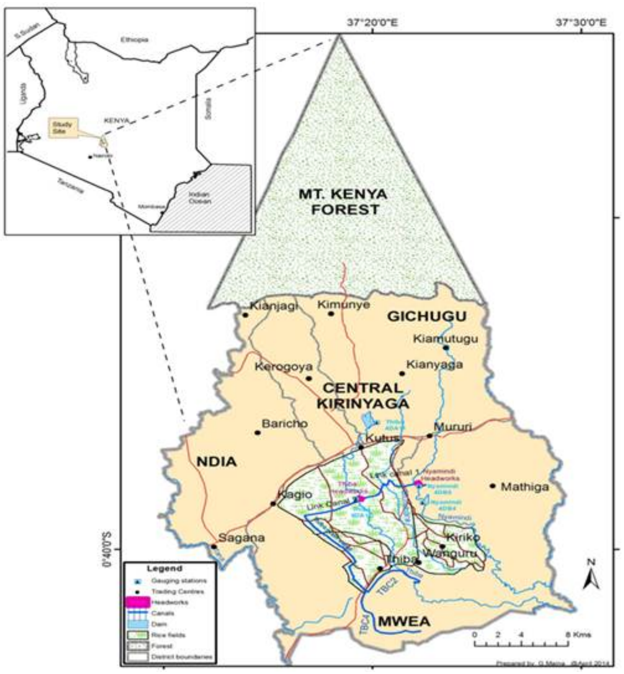

Figure 1: Map of Kirinyaga county showing Wanguru where the study was conducted

Kirinyaga county has temperatures ranging from a minimum of 12°C to a maximum of 26°C with an average of 20°C (Kaggikah, 2017). However, the mean monthly temperature in the area around the scheme is approximately 22.2°C with a minimum and maximum of 21.8°C and 24.0°C in January and March respectively (Serede*, et al.,* 2015). Higher temperatures are experienced during the rainy season. The soils have been classified previously as Vertisols. Rice, Maize and horticultural crops among them being tomatoes are grown under furrow irrigation in the scheme (Onderi, 2016).

Assessment of Tomato Plants for Bacteria Leaf Spot Symptoms

For the assessment, fourteen tomato farms were randomly picked for the assessment of bacteria leaf spot symptoms within Wanguru area in Mwea East between February and April 2019. Only farms covering a quarter acre and above were selected. Within the tomato farms, ten sampling positions at the distance gap of 5 meters were identified across by means of stratification. In every sampling position identified, three plants at the distance of one meter in front, left and on the right were evaluated for bacteria leaf spot symptoms.A total of 3000 tomato leaves in 100 tomato plants in 10 randomly selected farms were assessed. In each of the plants, ten leaves were randomly assessed for the symptoms and the average scored calculated for disease percent score. The plant leaves were considered to be infected with xanthomonads leaf spot by the presence of circular dark brown to black water-soaked lesions. Evaluation was followed by rating using scale 1-5 (Rao *et al.,* 2016)(Table 1).

Table 1:Bacteria leaf spot disease Score Criteria

Rating value	Disease %	Description
1	1 -5	Necrotic spot on the leaves
2	5 - 25	Necrotic spot on the leaves
3	25 – 50	Necrotic spot on the leaves
4	50 – 75	Necrotic spot on the leaves
5	75 – 100	Necrotic spot on the leaves

Disease Incidence Formula

Disease incidence is defined as the extent of infection in the field andwas calculated using the formula for Percentage of disease incidence (PDI) and Percentage of disease severity (PDS) as illustrated below.

$$\% PDI = \frac{TNFL}{TNLA} \times \underline{100}$$

TNFL = $TotalNumberofInfected$ leaves, TNLA = $TotalNumberof$ leaves $Assese$d

$$\% PDS = \frac{NIR}{NPA} \times \frac{100}{MS}$$

NIR = $NumberofIndividualRating$

NPA = $NumberofPlantsAssesed$

MS = $MaximumScale$

III. RESULTS

Figure 2: Bacterial leaf spottaken from Wanguru(Mwea)

A significant ($p<0.05$) variation in means of bacterial leaf spot occurredin all the tomato farms surveyed. Higher incidence was observed in farm 7 with mean of 16.000 % followed by farm 6 with mean of 14.667 %. the lowest incidence was recorded in farm 3 and 5 with mean incidence of 8.333 %. Five out of ten farms surveyed recorded means which were above general incidence mean of 11.828 % while the remaining farms had their means lower than the general mean (Table 2).

Table 2: Mean Separations of Incidences and Severity

Farm	Incidence (Means %)	Severity (Means %)
Farm7	16.000^{a}	33.333^{a}
Farm6	14.667^{ab}	31.000^{a}
Farm1	13.667^{abc}	30.000^{a}
Farm8	12.667^{abcd}	29.607^{a}
Farm4	12.333^{bcd}	28.333^{ab}
Farm10	11.500^{bcde}	25.333^{ab}
Farm2	11.000^{cde}	25.000^{abc}
Farm9	9.667^{de}	19.333^{abcd}
Farm3	8.333^{e}	$16.00o^{cd}$
Farm5	8.333^{e}	13.000^{d}
Mean	11.828	24.897
LSD ($p<0.05$)	3.575	9.329
CV	17.258	21.400

Means followed by the same letter in a column are not significantly differentat $p\leq0.05$).

A significant ($p<0.05$) variation in means of bacterial leaf spot severity was observed in tomato farms surveyed. Higher severity with mean of 33.333 % and 31.000 % was observed in farm 7 and farm 6 respectively. Lower bacteria leaf spot severity was observed in farm 3 and 5 with mean severity score of 16.000 % and 13.000 % respectively. Seventy per cent of the farms surveyed had a mean severity score above general mean of 24.897 % (Table 2).

Discussion

Incidence and Severity of BacterialLeaf Spot in Tomato Farms

Symptoms of a bacterial leaf spot disease in tomato caused by *Xanthomonas spp*were observed on different tomato farms surveyed in Wanguru area in Mwea. Characteristic necrotic lesions on the leaves appeared dark, circular, water-soaked and smaller in size across different farms. The aged leaf spot was brownish in colour and were angular in shape. Bacterial leaf spot disease symptoms observed were similar to those reported by Cerkauskas, (2005). Additionally, field observation by Ivey *et al.,* (2016) confirms the observation reported herein. They reported that bacterial spot was characterized by necrotic leaf spots with chlorosis on commercialtomato cultivars. Necrotic effect of bacterial leaf spot in the tomato tissue is brought about by bacterial virulence factors such as adhesins, polysaccharides, LPS and degradative enzymes. Pathogenicity factors like type III secretion system injects effector proteins into the host cell cytosol. Introduced virulent factors overcome plant cellular basal Defense mechanisms (Büttner and Bonas, 2010) leading to disease symptoms.

In the current study severity and incidence was statistically significant and differed from one farm to the next ($p<0.05$). Similarly, O'garro and Ward, (1989) reported variation in severity of the disease bacterial spot of peppers caused by *X. campestris pv. vesicatoria* in different areas of study noting that disease was most severe in the pepper fields of districts 4, 6 and 7 during survey period. Higher leaf spot disease incidence of upto 100% and foliar disease severity ranging from 20 to 80%, on a scale of 0 to 100% have been reported in commercial tomato cultivars (Ivey *et al.,* 2016). The higher incidence and severity of leaf spot disease can be attributed to the fact that the pathogen is spread by wind and water. Areas around Mwea that includes Wanguru has high temperature with high humidity due to irrigation farming and high plant density. The above conditions have been pointed out as an ideal environment for development and spread of leaf spot disease (Potnis *et al.,* 2015). In addition, the pathogen has ability to survive in crop residues, weeds and volunteer perennial hosts epiphytically or saprophytically existing in soil or on insects(López *et al.,* 1999; Roach *et al*, 2017). In host residues, according to Schaad *et al*., 1974) xanthomonad spp pathogen may survive in soil for up to two years. Varied survival sources and longer survival period provide and maintains inoculum for *Xanthomonads* infection thus, higher incidence and severity(Kocks *et al.,* 1998).

IV. CONCLUSION

This study reports lower incidences and severity of bacteria leaf spot caused by Xanthomonads species complex in tomato farms in Wanguru in Mwea, Kenya. The study should be extended to other parts of tomato production in Mwea.

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