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Incidence and Severity of Turcicum Leaf Blight Caused by *Exserohilum turcicum* (pass.) Leonard and Suggs) on Sorghum Populations in Different Regions of Tharaka Nithi County, Kenya

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Abstract Sorghum (Sorghum bicolor (L.) Moench) is a drought tolerant food crop preferred by subsistence farmers in dry areas which experience low annual rainfall. However, Turcicum Leaf Blight (TLB) caused by *Exserohilum turcicum* has threatened sorghum production in the world. New sorghum varieties have been introduced into the Kenyan production systems, including the drier parts of Tharaka Nithi County to boost yield and thus meet the increased demands for food and as a raw material by brewing industries. Nonetheless, challenges due to infection by TLB have negatively impacted on sorghum production resulting from damaged photosynthetic leaves. This study was conducted to determine the incidence and severity of TLB on sorghum populations in different regions of Tharaka Nithi County. Sorghum farms in eleven villages for the study were selected by multistage random sampling. The study was conducted between the month of January and June 2018. Data analysis was done by SAS software version 9.3 and significantly different means separated using LSD Test at 5% probability level. There was statistically significant variation in the severity and incidence of *E. Turcicum* leaf blight on sorghum population from different regions in Tharaka Nithi County (Pr > F<.0001). Disease TLB occurred in all the villages surveyed though at different frequencies. The disease incidence was higher at Kithaga, and Nkairini recording 74.45% and 55.93%. and lowest at Gatuntu and Gituntu both recorded the disease incidences 12.22%. Thus, farmers should be educated on sorghum TLB management for increased sorghum production and higher income to farmers.

Keywords Incidence, Severity, TLB, Sorghum, Tharaka-Nithi, Kenya

1. Introduction

Sorghum is the fifth most important cereal crop after wheat, maize, rice and barley [1] and a dietary staple food for millions of people worldwide [2, 3]. Nutritionally, sorghum provides energy, protein, vitamins and minerals [4]. It is a food security crop in most areas experiencing low annual rainfall [5] and takes about three to four months to mature. In Africa, sorghum ranks second after maize among cereals [6]. In East and Central Africa sorghum is grown in about 10 million hectares (ha) with Northern Sudan accounting for 21.4% of Africa's sorghum production, Ethiopia 7.3%, Tanzania 3.5%, Uganda 2%, Rwanda 0.8% and Kenya 0.6% [7] making Kenya an insignificant producer of sorghum in the region although the national demand for sorghum food product has increased tremendously [8]. In Kenya sorghum production is in the semi-arid low lands (Machakos, Kitui, Makueni, Mwingi, Embu, Tharaka Nithi, and Kajiado counties), moist-mid altitude (Busia, Siaya, Kakamega, Kisumu, Homabay, Kisii and Migori counties), cold semi-arid Highlands (Nakuru, Baringo, Laikipia and Taita Taveta Counties), Humid Coast (Kilifi, Lamu, Kwale, and Mombasa Counties [9, 10].

Low sorghum production in Kenya has partly contributed to food insecurity brought about by constraints like drought, pest and diseases which are determined by complex changes in crops and agricultural practice brought about by climate change [11]. Fungal diseases implicated in low sorghum production include, downy mildew (*Peronosclerospora sorghi*), Turcicum Leaf Blight (*Exserohilum turcicum*), Anthracnose (*Colletrotrichum sublineolum* Henn.) and sorghum smuts- (*Sporisorium sorghi* Ehrenberg (Link), loose smut (*Sphacelotheca cruenta* (Kuhn), Langdon and Fullerton) and long smuts (*Tolyposporium entrenbargii* (Kuhn) Pattouillard) [12]. Yield reductions due to TLB can be significant depending on disease severity, timing, and plant susceptibility [13]. However little attention has been given to study the significance of these fungal diseases in their role in low sorghum production.

Infection by TLB is particularly important due to its wide distribution and high grain losses associated with it in maize and sorghum farms [14]. There still exists a knowledge gap on the incidence and severity of TLB infestation in Tharaka Nithi County. Severe TLB Incidences in sorghum has been reported in neighbouring countries like Uganda [15] Ethiopia [12] and Sudan [16] but there is scanty information on the epidemiology of TLB in Kenya. In their work, [17] investigated the sorghum anthracnose (*Colletotrichum sublineolum*) and leaf blight (*Exserohilum turcicum*) in Busia county in Kenya, between 1994 and 1996 and reported that sorghum TLB was responsible for up to 1.5 % of yield loses. However, the knowledge on the occurrences of sorghum TLB in other regions in Kenya such as Tharaka Nithi County and its effect on production before this study was scanty.

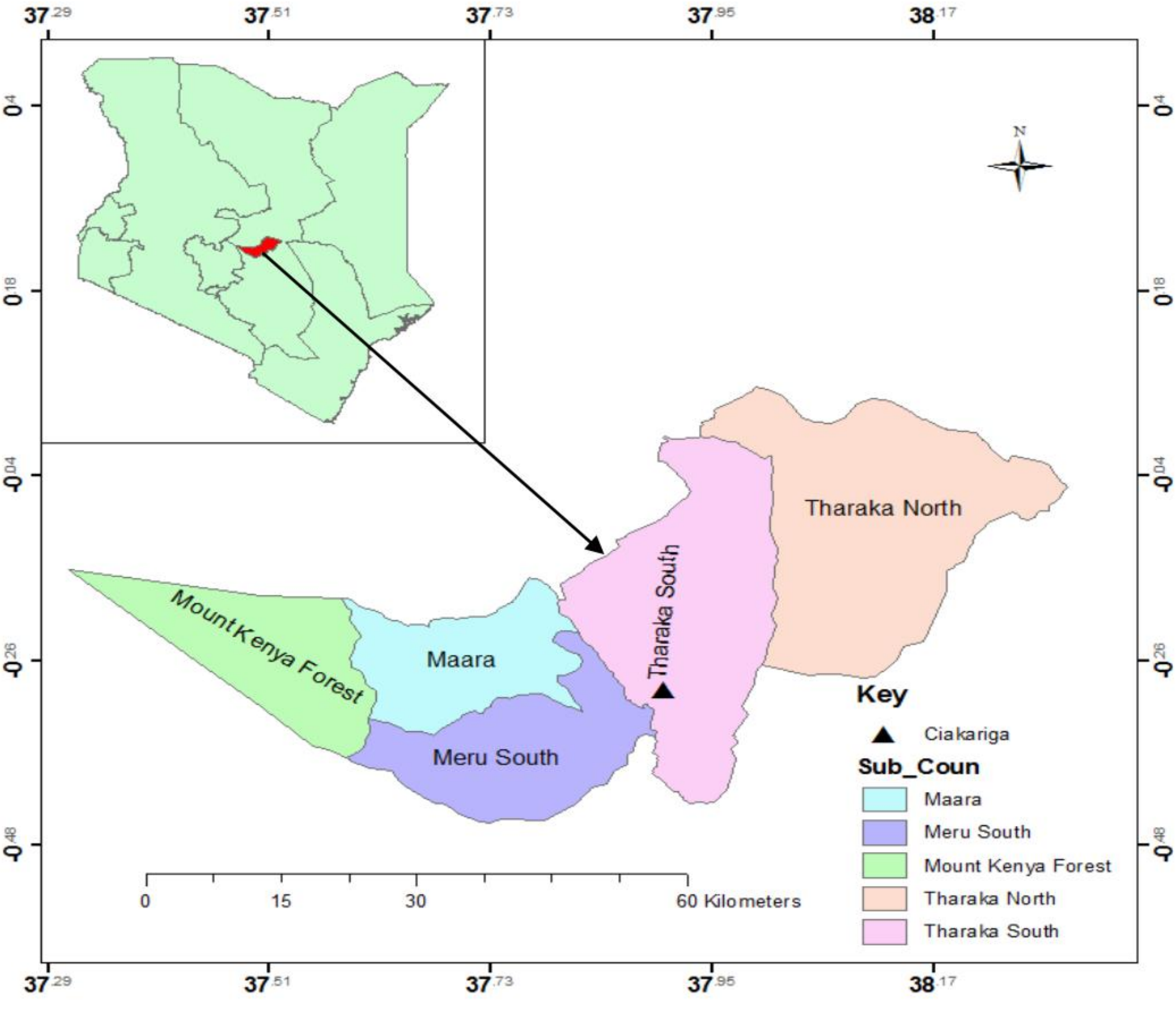

Figure 1: Map of Tharaka Nithi County [20]

Materials and Methods

Tharaka Nithi County borders the County of Embu to the South and South West, Meru to the North and North East, Kirinyiga and Nyeri to the West and Kitui to the East and South East. The county lies between latitude 000 07’ and 000 26’ South and between longitudes 37^0 19’ and 37^0 46’ East. The highest altitude of the county is 5,200m while the lowest is 600 m Eastwards in Tharaka. The average annual rainfall of 717 mm. The highlands (upper zone) comprise of Maara and Chuka which receive adequate rainfall for agriculture. The semi-arid (lower zone) covers Tharaka receiving less rainfall. The high-altitude areas have reliable rainfall. The lower regions receive low, unreliable and poorly distributed rainfall. Temperatures in the highland areas range between 14 ^oC to 30 ^oC while those of the lowland area range between 22 ^oC to 36 ^oC. Tharaka constituency experiences temperatures of up to 40 ^oC at certain periods. The county has a bi-modal rainfall pattern with the long rains falling during the months of April to June and the short rains in October to December [18]. Ferrasols soil which is highly weathered and leached is predominant in Tharaka Nithi County [19]. The soils in the experiment site are considered infertile as they are deficient in nitrogen (N) phosphorus (P) and zinc (Zn). Major crops in the area are; *Phaseolus vulgaris*, *Zea mays, Vigna unguiculate*, *Manihot esculenta*, *Cajanus cajan*, *Sorghum spp*., *Eleusine coracana* among others [18].

Survey Method for the Incidence and Severity of TLB on Sorghum Populations

The farms in this study were selected by multistage random sampling method [40]. From each constituency two wards were selected followed by selection of two villages. Sorghum farms in the selected village were listed from which two farms were picked randomly based on the history of growing sorghum for the study. The eleven villages were; Gatuntu, Gituntu, Kamwati, Kanwa, Kanyiritha, Kithaga, Kithinge, Mikuu, Miranji, Nkairini and Tunyai. At farm level stratified random sampling method was used to assess sorghum plants for TLB incidence. Ten sampling locations within sorghum farm were marked using etrex 30x Garmin GPS. Distance between sampling stations was four meters away. Three plants around the marked area at the distance of one meter in front, left and on the right were evaluated for TLB diseases occurrence based on spindle cigar shaped necrotic lesions, the typical characteristic of TLB. Evaluation was followed by rating using scale 1-6 according to Manu *et al* (Table 1) [21] and Sermons and Balint-Kurti [22].

Table 1: Disease Score Criteria

Rating value	% Leaf area infected	Description
1	0	Free from disease
2	1≤ 5	a few restricted lesions on the lower leaves
3	6≤10	several small and large lesions on many leaves
4	11≤25	Slight symptoms Moderate; many large lesions not coalesced
5	26≤40	Moderate symptoms; many enlarged and coalesced lesions
6	> 50	Very severe symptoms; coalesced lesions, leaf wilting, tearing and blotching

Disease Score Criteria Manu *et al* [21]

Disease Incidence Formula

Disease incidence defined as the extent of infection in the field, and calculated using the formula:

$$Diseases\ incidence\ (\%) = \frac{Number\ of\ infected\ plants}{Number\ of\ plants\ in\ the\ field}\ x\ 100$$

………Formula i

Percent disease index Formula

Severity results from the number and size of the lesions. Disease severity was calculated using the following formula

$$PDI = \frac{\text{Sum of numerical grading}}{2aleaves\ examined\ x\ maximum\ disease\ grading}\ X\ 100$$

………………………. Formula ii

Results

Incidence of Sorghum Turcicum Leaf Blight in Different Area of Tharaka Nithi County

There was a significant difference in incidences of TLB in the area of study ($p<0.05$). The highest infection rate by TLB was recorded at Kithaga location with an incidence value of 74.94% while the least infection rate was at Gatuntu with mean of 13.9500. Five villages; Kithaga, Nkairini, Kamwati, Kithinge and Kanwa recorded means above the overall mean of 34.58% while the 6 remaining villages recorded incidences below 34.58% (Table 2).

Table 2: Incidences of TLB at Different Locations in Tharaka Nithi County

Location	Incidence (%)
Kithaga	74.9367 [a]
Nkairini	54.0833 [b]
Kamwati	44.0767 [b c]
Kithinge	42.9633 [b c]
Kanwa	42.5800 [b c]
Mikuu	33.3400 [c d]
Miranji	24.4467 [c d e]
Kanyiritha	20.0000 [d e]
Tunyai	17.1767 [d e]
Gatuntu	13.9500 [d e]
Gituntu	12.8067 [e]
Mean	34.5782
LSD ($p\leq0.05$)	19.918
CV (%)	34.0178

[a]Means followed by the same letters are not significantly different at 5% probability level.

Severity of TLB Infection on Sorghum in Different Area of Tharaka Nithi County

There was a significant difference in severity of TLB in the area studied ($p<0.051$). The highest severity rate by TLB was recorded at Kanwa (21.06), while Kanyiritha recorded the lowest severity rate with mean of 4.36 (Table 3). Three villages including Kanwa, Mikuu and Kithinge recorded percentage severity above the overall mean of 11.03% while the rest recorded severity lower than 11.03%.

Table 3: TLB Severity of TLB at Different villages in Tharaka Nithi County

Location	Severity (%)
Kanwa	21.0600 [a]
Mikuu	20.5700 [a]
Kithinge	18.3133 [b]
Miranji	10.7233 [c]
Gatuntu	10.1800 [c]
Nkairini	9.3800 [c]
Gituntu	9.3700 [c]
Tunyai	6.9133 [d]
Kithaga	5.7500 [d e]
Kamwati	4.7100 [e]
Kanyiritha	4.3567 [e]
Mean	**11.0297**
LSD ($p\leq0.05$)	**2.1281**
CV (%)	**11.3943**

[a]Means followed by the same letters are not significantly different at 5% probability level.

Discussion

The TLB disease incidence and severity within 11 villages of Tharaka Nithi County showed high rates of infection. The infection rate varied from one village to the other with Kithaga being the most affected while Gituntu recording the lowest infection rate (Table 2). This variation in the rate of infection may partly be attributed to the presence of different fungal pathogen strains and cultivars found in different regions. Ogolla *et al.,* [23] reported existence of culturally and morphologically different *E. turcicum* isolates in Tharaka Nithi county which can attribute to varied incidences of sorghum TLB in most farms. Localities such as Gituntu and

Gatuntu mostly grow Mugana sorghum variety and recorded the lowest incidence of TLB infection, while areas such as Kithaga and Nkairini that grow Muruge and Kaguru experienced the highest disease incidence. Varietal preference clearly influenced disease incidence. The findings agree with those of Izge *et al*., [24] that sorghum varieties react differently to fungal infections, with some varieties being more susceptible. Susceptible varieties may be lacking genes associated with genomic regions or QTL (quantitative trait loci) which may resist TLB pathogen [25]. Increased TLB incidence has been attributed to factors such as breaking down of qualitative resistance, which is not stable and introduction of temperate susceptible germplasm into tropical environments [26]. The varieties mostly susceptible to most pathogens may possess vertical mode of pathogen resistance while those susceptible to fewer pathogen may be due to horizontal mode of pathogen resistance [27]. Results of TLB disease incidence revealed that farmers prefer Kaguru variety which is the most susceptible to TLB infestation, similar to findings by Beshir *et al*., [16]. However, the susceptible varieties such as Kaguru are preferred by farmers because they are high yielding and have better market price compared to other varieties.

Agronomic practices such as crop spacing are known to affect the spread of plant fungal diseases in several ways [28, 29]. Effects of narrow spacing of crops include changes in the number of targets hosts available to intercept inoculum as well as the spatial relationship between the hosts and spore dispersal gradients. Higher plant density in the farm can affect the splash dispersal of fungal conidia [30]. Narrow plant spacing causes more fruits to escape timely harvesting and contribute to increased levels of inoculum [28, 31]. Observation of sorghum farms in Tharaka Nithi County revealed narrow spacing which was the probable reason for the multiplication and spread of the pathogen. Narrow spacing modifies microclimate which may be suitable for pathogen development [30]. Additionally, most small-scale sorghum farmers in Tharaka Nithi County grow sorghum yearly in the same field, which may cause infection of the crop from pathogen inoculum or spores sustained by crop debris. Similar findings by Manu *et al.*, [21] showed that mono-cropped agricultural fields show more TLB disease index compared to mixed-cropped fields. Indeed, mono-cropped plants harbour fungal pathogens hence increasing the rates of spread [32, 33]. The higher spread of pathogen in a monocrop farms is also due to Pathogen inoculum accumulation [29]. In the study area, most of the sorghum farmers rarely use inorganic fertilizers. Yet, fertilizers application is claimed to be important for management of many diseases, since lack of fertilizer makes plants weak and hence more susceptible [34]. Adequate fertilizer application was observed to reduce the incidence of *Alternaria* leaf blight [34, 35]. It is plausible to argue that cultivation of sorghum without application of fertilizer in Tharaka Nithi County could be a contributing factor for increased incidence and severity of the sorghum TLB disease.

Results from this study revealed that TLB incidence and severity is a major constraint to sorghum production in Tharaka Nithi County. Thus, an integrated management system which involves the use of diseases control methods such as biological control, use of resistant cultivars and application of fungicides are necessary. Further efforts are also required on maintenance of high standards of hygiene in conducting cultural practices and legislation that restricts use of unregulated seed systems are required to mitigate further disease spread. Previous studies have shown success in use of biological control agents (BCAs) to control TLB in maize. The BCAs previously used include *Bacillus spp.* [36], epiphytic bacteria [37, 36] and antifungal compounds-producing bacteria that inhibit leaf blight disease [38]. Resistant cultivars and chemical control with mixtures of fungicides have also shown success in controlling TLB in maize [39].

Conclusion and Recommendations

The results obtained indicated that TLB incidence and severity varied from one village to the other in Tharaka Nithi county and the incidences are influenced heavily by the agronomic practices.

The study recommends that the county government should educate sorghum farmers on best farm practices to contain and manage TLB spread in the region.

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