PREVALENCE OF BEAN ROOT ROT PATHOGENS IN THARAKA NITHI COUNTY, KENYA

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Abstract— Kenya is among the top common bean producing countries globally with an annual production of 0.76 million tonnes worth Ksh. 60 billion. However, its production faces several biotic and abiotic challenges. Among these challenges is the root rot disease, which causes an estimated yield loss of 70% every year. The disease is caused by several soilborne pathogens, making it difficult to control through use of cultural practices, chemicals and development of tolerant varieties. This study was carried out in five bean growing agroecological zones in Tharaka Nithi County, Kenya during the long rains season (March to April) of 2023. The aim of the study was to determine the prevalence of the root rot disease pathogens in different agroecological zones in the county. A descriptive survey design was used to collect data on prevalence of the disease in farms. Analysis of variance was used to determine if there were significant differences in prevalence between different agro-ecological zones. Further the significant means were separated using Least Significant Difference at $\alpha = 0.05$. The findings of the study showed that bean root rot disease was caused by four main soilborne microorganisms including *Fusarium*, *Macrophomina*, *Pythium* and *Rhizoctonia* spp which occurred in all agroecological zones of the county. The highest disease prevalence (37.58%) was in AEZ UM3 followed by LM4 (34.17%), LM5 (20.63%), UM2 (18.2%) and UM1 (16.76%) respectively. Additionally, the prevalence of the disease pathogens varied significantly ($p < 0.05$) across the agroecological zones in the county. Therefore, appropriate measures should be employed to control and reduce yield loss associated with the disease.

Keywords— Agroecological Zone, Common Bean, Prevalence, Root Rot Disease.

I. Introduction

Common bean (*Phaseolus vulgaris* L.) is among the most widely cultivated legumes across the world [1]. The crop is directly consumed by 400 million people in Africa and 250 million people in South and Central America [2]. It is consumed by people in form of cooked pods, leaves or seeds [3]. In most cases, they are cooked with cereals for a balanced diet to deal with malnutrition [4]. Common bean is a major source of protein, carbohydrates and useful micronutrients [1]. Additionally, it is a source of income to majority of households in rural areas in Sub Saharan Africa [5].

Common bean production is a widespread farming practice in Latin America, Asia and sub-Saharan Africa [6]. Approximately 28.9 million metric tonnes of dry bean are produced annually from 33.1 million hectares worldwide [7]. Myanmar, India, Brazil, China and America are the top ranked bean producing countries in the world [3]. In Africa, 7.1 million metric tonnes of common bean are produced from an area of 7.8 million hectares. Kenya is ranked ninth in the world and third in East Africa as dry bean producer with approximately 0.76 million metric tonnes annually [7]. In Kenya, the common bean is cultivated by more than three million farmers in Central, Rift Valley, Coast, Western, Nyanza and Eastern regions [8]. The dry bean production in Tharaka-Nithi county, is estimated to be around 6 015 tonnes from an estimated area of 6 928 hectares [9].

Several biotic and abiotic factors that seriously compromise yields of common beans [10]. One of the major factors affecting bean yields is the root rot disease [11]. The disease is caused by several soil borne pathogenic fungi and oomycetes [12]. The pathogens include: *Fusarium* spp (fungus), *Macrophomina* spp (fungus), *Pythium* spp (oomycete) and *Rhizoctonia* spp [(fungus) 13]. However, there is limited information on prevalence of the bean root rot disease in different agroecological zones (AEZ) in Tharaka Nithi County, Kenya. The study found that multiple soil-borne pathogens, prevalent in all bean-growing AEZ across the county, caused the disease. These pathogens include *Fusarium, Macrophomina, Pythium, and Rhizoctonia* spp. The disease prevalence in different AEZ was as follows UM3 (37.58%), LM4 (34.17%), LM5 (20.63%), UM2 (18.2%) and UM1 (16.76%) respectively. In addition, the was significant ($p < 0.05$) variation of disease pathogens across the agroecological zones in the county. Therefore, this study provides useful information on the prevalence of root rot pathogens in different bean growing AEZ in Tharaka Nithi County, Kenya, thus critical in choosing appropriate strategies to control them.

II. MATERIALS AND METHODS

A. Study Area

The study was carried out in the major bean growing agroecological zones in Tharaka Nithi County, Kenya. The county borders the counties of Embu to the south and southwest, Kirinyaga and Nyeri to the west, Meru to the north and northeast, and Kitui to the east and southeast. It lies between latitude 00° 07' and 00° 26' South and between longitudes 37° 19' and 37° 46' East. The highest altitude in the county is 5,200 m in Chuka and Maara while the lowest is 600 m in Tharaka. The county is divided into six main agroecological zones (AEZ). These AEZ include upper midland UM 1, 2, 3, and 4, Lower midland 4 (LM 4), and Lower midland 5 (LM 5) [14]. The upper midland zones receive adequate rainfall for farming and the temperatures range between 14 °C to 30 °C. The lower zones are semi-arid and receive less rainfall with the temperature range between 22 °C and 36 °C or sometimes up to 40 °C. The main types of soil in the agroecological zones are nitisols, ferrasols, regosols and vertisols. The soils have a pH range between 4.41 to 7.16 with low amount of organic carbon [15]. The relative humidity across the agroecological zones ranges between 40-80 % depending on the time of the year [16]. Specifically, the study was conducted in LM 5, LM 4, UM 3, UM 2 and UM 1 (Fig. 1).

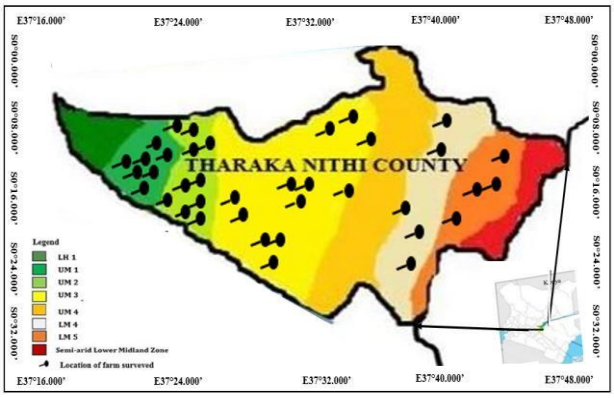

Fig. 1. A Map Showing the Location of the Surveyed Farms in the Study Area

B. Sample Size Determination, Target Population and Sampling Method

The population of the study was bean farms within the five agroecological zones in Tharaka Nithi County: LM 5, LM 4, UM 1, UM 2, and UM 3. There were estimated 23650 dried bean farms within these agroecological zones (Personal Communication with Sub-county agricultural officer, Maara, 25/10/2021). The target population was all bean farmers in the five agroecological zones across Tharaka Nithi County. The sample size was determined as follows [17].

$$n = \frac{p(1-p)}{\frac{e^2}{z^2} + \frac{p(1-p)}{N}} \quad (1)$$

where, n= sample size, N= population size (23650), e = acceptable sampling error (e = 0.05), p = population proportions (p = 0.5), z = z value at reliability level 95 % or significance level 0.05; z = 1.96.

Hence, 378 farms were randomly selected within the five agroecological zones surveyed.

C. Sampling Procedures

A cluster random sampling was used in this study. The five agro ecological zones; (LM 5, LM 4, UM 1, UM 2, and UM 3), constituted the clusters. Sample size distribution among the five agro ecological zones was as given in the Table 1.

Table 1. Sample size distribution among the five agroecological zones of Tharaka Nithi County

Agroecological Zone	Number of Farms	Sample Size
LM 4	3153	50
LM 5	2562	41
UM 1	4139	66
UM 2	6307	101
UM 3	7489	120
Total	23650	378

D. Data Collection

Three hundred and seventy-eight bean farms in the county were surveyed to assess the prevalence of bean root rot disease. Ten plants along equally spaced parallel transects were randomly selected and observed for the presence or absence of root rot disease symptoms in each sampled farm. Data on number of diseased plants was recorded in tabular form. The symptoms displayed by each diseased plant were observed and recorded. Then, the symptoms recorded were matched with those of root rot diseases described in the International Center for Tropical Agriculture (CIAT) handbook for bean disease and pest identification [16]. This enabled systematic identification of bean root rot diseases.

The prevalence of the disease in the different agroecological zones was calculated as follows [18],

$$\text{Disease prevalence (\%)} = \frac{\text{Farms with disease}}{\text{Total farms surveyed}} \times 100$$

E. Data Analysis

Descriptive statistics were used to summarize data into means and percentages. Analysis of variance (ANOVA) was used to determine the effect of the agroecological zones on prevalence of root rot disease ($\alpha = 0.05$). Mean separations were done using least significant difference (LSD) at $\alpha = 0.05$.

III. RESULTS

Bean root rot disease in Tharaka Nithi County, Kenya was caused by 4 main pathogens which *include Fusarium, Macrophomina, Pythium and Rhizoctonia* spp. The disease was prevalent in all the 5 bean growing agroecological zones of the county. The highest bean root rot disease prevalence (37.58%) was recorded in AEZ UM3 followed by LM4 (34.17%). Agroecological zone LM5, UM2 and UM1 had a disease prevalence of 20.63%, 18.2% and 16.76% respectively Table 3.

Table 3. Common Bean Root Rot Disease Prevalence in Different Agroecological Zones in Tharaka Nithi County

			Prevalence			
AEZ	**Root rot diseases**	**N**	**Mean (%)**	**Mean (%)**	**Cv (%)**	**Lsd (α = 0.05)**
LM4	Fusarium	5	46.48 [a]	34.17	9.05	4.146
	Macrophomina	5	31.16 [c]			
	Pythium	5	22.18 [d]			
	Rhizoctonia	5	36.84 [b]			
LM5	Fusarium	5	21.66 [b]	20.63	14.18	3.921
	Macrophomina	5	27.74 [a]			
	Pythium	5	13.1 [c]			
	Rhizoctonia	5	20 [b]			
UM1	Fusarium	5	41.4 [a]	16.76	9.73	2.183
	Macrophomina	5	2.36 [d]			
	Pythium	5	12.86 [b]			
	Rhizoctonia	5	10.32 [c]			
UM2	Fusarium	5	36.32 [a]	18.2	15.33	3.740
	Macrophomina	5	6.12 [d]			
	Pythium	5	18.64 [b]			
	Rhizoctonia	5	11.72 [c]			
UM3	Fusarium	5	57.24 [a]	37.58	6.266	3.157
	Macrophomina	5	18.92 [d]			
	Pythium	5	32.76 [c]			
	Rhizoctonia	5	41.4 [b]			

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

There was significant ($p < 0.05$) variation of the prevalence of the various common bean root rot diseases among the AEZs. In all the five bean growing agroecological zones, $p = .0001$ Table 4. In AEZ LM4, Fusarium root rot diseases had the highest prevalence (46.48%). Rhizoctonia, Macrophomina and Pythium root rot disease had a prevalence of 36.48%, 31.16% and 22.18% respectively. In AEZ LM5, Macrophomina root rot was the most prevalent (27.74%) followed by Fusarium root rot (21.66%) and Rhizoctonia root rot (20.0%). Pythium root rot had the least prevalence (13.1%) in the AEZ. In AEZ UM1, Fusarium root rot was the most prevalent (41.4%), followed by Pythium (12.86%). Rhizoctonia and Macrophomina root rot diseases had prevalence rates of 10.32% and 2.36% respectively.

In AEZ UM2, Fusarium root rot had the highest prevalence (36.32%). Pythium and Rhizoctonia root rots had a prevalence of 18.64% and 11.72% while Macrophomina root rot had the least prevalence (6.12%). In AEZ UM3, Fusarium was the most prevalent (57.24%) followed by Rhizoctonia root rot (41.4%). Pythium root rot had a prevalence of 32.76% while Macrophomina root rot disease had the least prevalence (18.92%) Table 3.

Table 4: Analysis of Variance for the Prevalence of Bean Root Rot Disease in Different Agroecological Zones in Tharaka Nithi County

Source	DF	Sum of Squares	Mean Square	F Value	P value
ANOVA for the Prevalence of Bean Root Rots in LM4					
Pathogen	3	1557.43	519.14	54.30	<.0001
Error	16	152.98	9.56		
Corrected Total	19	1710.41			
ANOVA for the Prevalence of Bean Root Rots in LM5					
Pathogen	3	543.55	181.18	21.18	<.0001
Error	16	136.86	8.55		
Corrected Total	19	680.42			
ANOVA for the Prevalence of Bean Root Rots in UM1					
Pathogen	3	4355.85	1451.95	547.49	<.0001
Error	16	42.43	2.65		
Corrected Total	19	4398.29			
ANOVA for the Prevalence of Bean Root Rots in UM2					
Pathogen	3	2582.22	860.74	110.60	<.0001
Error	16	124.52	7.78		
Corrected Total	19	2706.74			
ANOVA for the Prevalence of Bean Root Rots in UM3					
Pathogen	3	3862.68	1287.56	232.17	<.0001
Error	16	88.73	5.55		
Corrected Total	19	3951.41			

IV. Discussion

The study revealed that the disease in Tharaka Nithi county, Kenya was caused by several microorganisms which include *Fusarium*, *Pythium*, *Rhizoctonia* and *Macrophomina* spp. These observations concur with the study findings which showed that the disease in legumes in Busia County, in western Kenya was caused by multiple pathogens including *F. solani*, *F. oxysporum*, *Macrophomina* spp., *Pythium* spp., and *Rhizoctonia* spp [19]. In addition, several studies across Sub Saharan Africa have also shown that the disease in beans is caused by a complex of oomycete and fungal pathogens [13, 19]. On the other hand, the study showed that the disease pathogens occurred in all bean growing agroecological zones of the county. This would be attributed to the diversity of the pathogens which caused the disease in common bean. However, there was high prevalence of root rot diseases in AEZ UM 3 (37.58 %) [Table 3] as compared to other AEZs. The low temperatures (19-21 °C) and high relative humidity (60-70%) in this AEZ, were favourable to the thriving of the bean root rot pathogens [20]. These observations align with previous findings which showed that planting seeds in cold soil increases the incidences of root rot disease in faba bean [21]. Low prevalence of the disease in AEZ UM 1, may be attributed to the high humidity (70-80%) but very low temperature (14-19 °C) characterizing the AEZ [22]. Common bean is a warm-season crop (17.5-27 °C), hence there was limited bean farming in this AEZ leading to low prevalence of the disease [23, 24].

There was significant variation of the prevalence of the bean root rot diseases among the bean growing agroecological zones of the county. The disparity in prevalence may be attributed to the variations in environmental conditions which favoured or hindered the multiplication of the pathogens [25]. Generally, Fusarium spp had the highest prevalence compared to other root rot disease pathogens in UM 3 (57.24 %), UM 2 (36.32 %), UM 1 (41.4 %) and LM 4 (46.48 %) [Table 3]. This may be attributed to favourable environmental conditions in these AEZs that promoted the proliferation of the pathogen [13]. In general, the UM1, UM2 and UM3 agroecological zones are characterized by low temperatures (14-21 °C) and high humidity (60-80 %) that favour thriving of *Fusarium* spp [25]. In addition, the predominant nitrosols type of soil in these AEZs is acidic with low amount of organic carbon which favour growth and reproduction of *Fusarium* spp [16]. The high prevalence of *Fusarium* spp pathogens also might be due to the number of *Fusarium* species which cause the disease in plants. Previous study findings showed that eight species of *Fusarium* caused the root rot disease in legumes [26]. On the other hand, the highest prevalence of Macrophomina root rot disease was observed in LM 5 (27.74 %) and LM 4 (31.16 %) [Table 3]. These AEZs are characterized by high temperature (28-35 °C) and relative low humidity (40%) [27]. Consequently, the high prevalence of Macrophomina root rot in these AEZs may be associated with the high temperatures and drought stress conditions which favoured infection of host plants [27]. These results align with the study findings which showed that high temperature (28-35 °C) and low water

potential (40%) are favourable for development of charcoal root rot disease in mung bean and urdbean [28].

V. Conclusion

This study showed that bean root rot disease is prevalent in all bean growing agro-ecological zones in Tharaka nithi county, Kenya. However, the prevalence of the root rot disease in common bean varies with the agro-ecological zones due to the difference in environmental factors in the AEZs. In addition, the disease is caused by multiple soil borne pathogens which include *Fusarium* spp., *Pythium* spp., *Rhizoctonia* spp and *Macrophomina* spp. The findings showed that root rot disease caused by *Fusarium* spp had the highest prevalence across the AEZs in the county.

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VI. References

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