EFFECT OF CATTLE MANURE VERMICOMPOST ON BEAN ROOT ROT PATHOGENS IN THE GREENHOUSE POT EXPERIMENTS

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Abstract— The root rot disease in beans is one of the limiting factors affecting common bean production worldwide. Under favourable conditions, the disease can cause yield losses of up to 75%. Control and management strategies of the disease mostly involve the use of fungicides. However, this method is expensive for the majority of farmers, and excessive use of fungicides is detrimental to the environment. Therefore, researchers extensively explore eco-friendly alternatives to minimise adverse effects and the use of synthetic fungicides. One of such options is the use of cattle manure vermicompost. The study was conducted from March to April 2023 at the research greenhouse of the department of plant science of the faculty of agriculture of Chuka University, Kenya. The objective of the study was to determine the effect of cattle manure vermicompost on the severity of root rot in beans in the greenhouse pot experiments. An experimental research design was used to collect data on the effect of cattle manure vermicompost on the severity of pathogens causing bean root rot in the greenhouse pot experiments. Analysis of variance was used to determine if there was a significant effect of cattle manure vermicompost on the severity of root rot pathogens in beans in the greenhouse pot experiments. The Least Significant Difference was used for separation of significant means at $\alpha = 0.05$. The study findings showed that cattle manure vermicompost significantly reduced the severity of root rot disease in beans during greenhouse pot experiments ($p < 0.05$). The maximum suppression effect of the disease was observed at a 40% amendment of cattle manure vermicompost, with the lowest disease severity index between 0 and 3.3. Therefore, the management of root rot disease in bean production should incorporate cattle manure vermicompost.

Keywords— cattle manure vermicompost, common bean, root rot pathogen, greenhouse pot experiment, severity.

I. INTRODUCTION

Root rot disease is of considerable significance in bean-growing areas in many parts of the world [1]. Generally, the disease affects the root system of the plant, thus interfering with the absorption of water and mineral salts from the soil [2]. In Sub-Saharan Africa, yield losses of up to 75% in common bean production have been associated with the disease [3]. Several species of soil-borne pathogens cause the disease [1]. Those who grow beans in western, central, and eastern Kenya are most likely to have pathogens like *Fusarium*, *Rhizoctonia*, *Pythium*, and *Macrophomina* spp. [1, 4]. On the other hand, a continuous decline in bean yields has been attributed to an increase in the prevalence of the disease pathogens in bean-growing areas [5]. To mitigate the yield losses, the most common disease management strategy applied is the use of fungicides [6]. However, most fungicides are costly, hence unaffordable to the majority of poor farmers; excessive and prolonged use results in environmental and health hazards [6, 7]. Notwithstanding, the pathogens produce resistance structures that persist and survive in the soil for a long period [8, 9].

Therefore, there is a necessity to explore alternative, effective, and environmentally friendly disease management strategies [1, 6]. Using cattle manure vermicompost (CMV) is one promising method for managing root rot disease. Many beneficial microbes, like *Actinomycetes*, *Aspergillus*, and *Trichoderma* spp, live in vermicomposts. These microbes stop the growth and spread of several plant pathogens [10, 11, 12]. Pest-repelling and nematode-killing properties make them useful for getting rid of aphids, mealy bugs, spider mites, cabbage white caterpillars, cucumber beetles, and tobacco hornworms [12, 13, 14]. However, there are few scientific studies on the utilisation of CMV for the management of root rot disease in common bean production in Kenya. The study findings showed that CMV significantly reduced the severity of bean root rot pathogens in greenhouse pot experiments ($p < 0.05$). Maximum suppression effect of the disease was observed at 40% of CMV, with the lowest disease severity between 0 and 3.3. Therefore, this study provided useful information on the effect of CMV on root rot pathogens; thus, CMV may be used as an alternative strategy for managing root rot disease in bean production.

II. MATERIALS AND METHOD

A. Study Area, Plant Sowing, and Treatment Application

This study was carried out from March to April 2023 at the research greenhouse of the department of plant science of the faculty of agriculture of Chuka University, Kenya. The experiments used plastic pots with a diameter of 70 mm and a height of 95 mm, each containing 0.1 kg of sterile red soil. The soil was sterilized before use by autoclaving it at 121°C for 2 hours. Different pots were inoculated with 2 ml of spore and mycelial suspension from preserved pure cultures of isolates from four different root rot pathogens, which included *Fusarium solani, Macrophomina phaseolina, Pythium aphanidermatum,* and *Rhizoctonia solani*. Pots that were not infected in each treatment served as the control treatment. The pots were then watered every two days for a period of eight days. Later on, soil in the 15 pots per treatment was amended with 0 kg (0%), 0.01 kg (10%), 0.02 kg (20%), 0.03 kg (30%), and 0.04 kg (40%) of CMV 48 hours before sowing. Three common dry bean varieties, namely Katumani B1, Mwitemania, and Kathika/Yellow beans, were planted in the pots. All seeds were surface sterilised with 1% sodium hypochlorite for 10 minutes and then air-dried before planting. A single seed was planted per pot. Each treatment was replicated three times. The pots were maintained in a greenhouse and lightly watered every second day for two weeks.

B. *Experimental Design*

3 x 4 x 5 factorial experiment, laid out in a Complete Randomized Design (CRD), was used to determine the effect of CMV on the isolates of the pathogen causing bean root rot in the greenhouse pot experiments. There were three factors comprising common bean varieties (at three levels), bean root rot pathogen (at four levels), and different CMV concentrations (% by mass (at five levels). The study resulted in 60 treatments, and each treatment was replicated three times.

C. *Data Collection*

On the fourteenth day after sowing, disease assessment was done by examining the seedlings for symptoms of root rot. Five seedlings for each treatment were randomly selected. The selected plants were then uprooted with care not to damage roots and hypocotyls. After that, the roots were cleaned with pure tap water to get rid of any dirt or debris. A scale of 0-4 was used to score the disease severity index of the different disease pathogens [15]. The disease severity index was calculated as a percentage using the following formula:

$$DSI\ (\%) = (\Sigma nv)/4N \times 100$$

where, DSI = Disease Severity Index, Σ = Summation, n = number of plants in each category, v = numerical values of symptoms category, N = total number of plants sampled, 4 = Maximum numerical value of symptom category.

Table 1: Disease Severity Rating Scale for Bean Root Rot

Scale	Reaction	Host response
0	No lesions	Resistant
1	A few lesions on hypocotyl and roots covering up to 25%	Moderately resistant
2	Many lesions on hypocotyl and roots covering up to 50%	Less resistant
3	Many lesions covering up to 75% and wilting	Susceptible
4	Pre-emergence damping-off	Highly susceptible

III. Data Analysis

Descriptive statistics was used to summarise data into means, percentages, and standard deviations. One-way ANOVA was used to determine the severity root rot pathogens were in the greenhouse pot experiment. SAS version 9.4 was used for the analysis. The ANOVA was used to determine the effect of cattle manure vermicompost on the severity index of root rot pathogens in beans in the greenhouse pot experiments at α = 0.05. The significant means were separated using LSD at α = 0.05.

IV. Results

The severity of root rot diseases in beans differed significantly ($p<0.05$) [Table 2] after treatment with CMV at a concentration of 0%. In the Mwitemania bean variety, the most severe disease was Rhizoctonia root rot (50%), followed by Fusarium and Pythium root rots at 48.3% each. Macrophomina root rot had the lowest severity at 40%. For Katumani bean variety, Pythium root rot disease had the highest severity (51.7%), followed by Macrophomina (48.3%) and Fusarium (38.3%). Rhizoctonia root had the lowest severity (36.7%). For the Kathika bean variety, Pythium root rot had the highest severity (53.3%), followed by Rhizoctonia root rot (51.7%). Both Macrophomina and Fusarium root rots had the lowest severities, each at 43.3% [Table 3].

Table 2: Analysis of Variance for the Effect of Different Concentration of Vermicompost on Bean Root Rot Disease Severity in the Greenhouse Pot Experiment

Source	DF	Sum of Squares	Mean Square	F Value	P value
		ANOVA for the Severity on Mwitemania Variety at 0%			
Pathogen	3	189.58	63.19	3.79	0.06
Error	8	133.33	16.67		
Corrected Total	11	322.92			

ANOVA for the Severity on Katumani Variety at 0%					
Pathogen	3	489.58	163.19	19.58	0.0005
Error	8	66.67	8.33		
Corrected Total	11	556.25			
ANOVA for the Severity on Kathika Variety at 0%					
Pathogen	3	189.58	63.19	7.58	0.0100
Error	8	66.67	8.33		
Corrected Total	11	256.25			
ANOVA for the Severity on Mwitemania Variety at 10%					
Pathogen	3	508.33	169.44	11.62	0.0028
Error	8	116.67	14.58		
Corrected Total	11	625.00			
ANOVA for the Severity on Katumani Variety at 10%					
Pathogen	3	922.92	307.64	29.53	0.0001
Error	8	83.33	10.42		
Corrected Total	11	1006.25			
ANOVA for the Severity on Kathika Variety at 10%					
Model	3	739.58	246.53	16.90	0.0008
Error	8	116.67	14.58		
Corrected Total	11	856.25			
ANOVA for the Severity on Mwitemania Variety at 20%					
Pathogen	3	216.67	72.22	6.93	0.0129
Error	8	83.33	10.42		
Corrected Total	11	300.00			
ANOVA for the Severity on Katumani Variety at 20%					
Pathogen	3	356.25	118.75	5.70	0.0219
Error	8	166.67	20.83		
Corrected Total	11	522.92			
ANOVA for the Severity on Kathika Variety at 20%					
Pathogen	3	283.33	94.44	11.33	0.0030
Error	8	66.67	8.33		
Corrected Total	11	350.00			
ANOVA for the Severity on Mwitemania Variety at 30%					
Pathogen	3	156.25	52.08	2.08	0.1808
Error	8	200.00	25.00		
Corrected Total	11	356.25			
ANOVA for the Severity on Katumani Variety at 30%					
Pathogen	3	108.33	36.11	4.33	0.0432
Error	8	66.67	8.33		
Corrected Total	11	175.00			
ANOVA for the Severity on Kathika Variety at 30%					
Pathogen	3	50.00	16.67	2.00	0.1927
Error	8	66.67	8.33		
Corrected Total	11	116.67			
ANOVA for the Severity on Mwitemania Variety at 40%					
Pathogen	3	6.25	2.08	0.25	0.8592
Error	8	66.67	8.33		
Corrected Total	11	72.92			
ANOVA for the Severity on Katumani Variety at 40%					
Pathogen	3	8.33	2.78	0.67	0.5957
Error	8	33.33	4.17		
Corrected Total	11	41.67			
ANOVA for the Severity on Kathika Variety at 40%					
Pathogen	3	6.25	2.08	1.00	0.4411
Error	8	16.67	2.08		
Corrected Total	11	22.92			

The severity of root rot diseases in beans differed significantly (p<0.05) [Table 2] after treatment with CMV at a concentration of 10%. In the Mwitemania bean variety, Pythium root rot was the most severe root rot disease (43.3%). Rhizoctonia and Fusarium root rots followed with severities of 41.7% and 38.3%, respectively. Macrophomina root rot had the lowest severity (26.7%). For the Katumani bean variety, the severity of Pythium root rot was highest (48.3%), followed by Macrophomina root rot disease at 46.7%. Fusarium and Rhizoctonia root rots had the lowest severity, each at 30%. In the Kathika bean variety, the severity of Pythium root rot disease was the highest (48.3%). Rhizoctonia, Macrophomina, and Fusarium root rot disease severities were 46.7%, 41.7%, and 28.3% respectively [Table 3].

The severity of bean root rot diseases differed significantly (p<0.05) [Table 2] after treatment with CMV at a concentration of 20%. In the Mwitemania bean variety, the most severe root rot disease was Rhizoctonia (35%), followed by Pythium root rot (31.7%) and Fusarium root rot disease (30%), respectively. Macrophomina root rot had the lowest severity (23.3%). For the Katumani bean variety, the severity of Pythium and Macrophomina root rot disease was highest, each at 33.3%, followed by Fusarium root rot at 23.3%. Rhizoctonia root rot had the lowest severity (21.7%). In the Kathika bean variety, Pythium and Macrophomina root rot diseases were the most severe (33.3%). Rhizoctonia and Fusarium root rot diseases had severities of 31.7% and 21.7%, respectively [Table 3].

The severity of root rot diseases in beans differed significantly (p<0.05) [Table 2] after treatment with CMV at a concentration of 30%. For the Mwitemania bean variety, the most severe root rot disease was Pythium (23.3%), followed by Fusarium (20%) and Macrophomina (18.3%), respectively. The severity of Rhizoctonia root rot disease was `the lowest (13.3%). In the Katumani bean variety, Macrophomina caused the most severe root rot (21.7%), followed by Pythium root rot (16.7%), and Rhizoctonia root rot (13.3%) respectively. For the Kathika bean variety, Pythium root rot disease had the highest severity (21.7%), followed by Fusarium root rot (18.3%). Severities of Rhizoctonia and Macrophomina root rot diseases were 16.7% and 12.8%, respectively [Table 3].

There was no significant difference observed in disease severity (p > 0.05) [Table 2] after treatment with CMV at a concentration of 40%. For the Mwitemania bean variety, Fusarium root rot had the highest severity (3.3%), while those of Macrophomina, Pythium, and Rhizoctonia root rots were each at 1.7%. In the Katumani bean variety, Macrophomina and Pythium root rots were the most severe (1.7%), while both Fusarium and Rhizoctonia root rots had the least severity (0%). For the Kathika bean variety, Pythium root rot had the highest severity (1.7%), while Fusarium, Macrophomina, and Rhizoctonia root rots had the lowest severity (0%) [Table 3].

Table 3: Disease Severity (%) of Bean Root Rot at Different Cattle Manure Vermicompost Concentration in Greenhouse Pot Experiment Seven Days after Planting

Path	N	Mwit[1]	Kat[2]	Kath[3]	Mwit[1]	Kat[2]	Kath[3]	Mwit[1]	Kat[2]	Kath[3]	Mwit[1]	Kat[2]	Kath[3]	Mwit[1]	Kat[2]	Kath[3]
		Verm[8] (0%)			Verm[8] (10%)			Verm[8] (20%)			Verm[8] (30%)			Verm[8] (40%)		
Rhiz[4]	3	50.0^{a}	36.7^{b}	51.7^{ab}	41.7^{a}	30^{b}	46.7^{a}	35.0^{a}	21.7^{b}	31.7^{a}	13.3^{b}	13.3^{b}	16.7^{ab}	1.7	0	0
Pyth[5]	3	48.3^{a}	51.7^{a}	53.3^{a}	43.3^{a}	48.3^{a}	48.3^{a}	31.7^{a}	33.3^{a}	33.3^{a}	23.3^{a}	18.33^{ab}	21.7^{a}	1.7	1.7	1.7
Fus[6]	3	43.3^{ab}	38.3^{b}	43.3^{c}	38.3^{a}	30^{b}	28.3^{b}	30^{a}	23.3^{b}	21.7^{b}	20.0^{ab}	16.7^{ab}	18.3^{a}	3.3	0	0
Mac[7]	3	40.0^{b}	48.3^{a}	43.3^{c}	26.7^{b}	46.7^{a}	41.7^{a}	23.3^{b}	33.3^{a}	33.3^{a}	18.3^{ab}	21.7^{a}	12.8^{b}	1.7	1.7	0
Means		45.42	43.75	48.75	37.5	38.75	41.25	30	27.92	30.0	18.75	17.5	18.33	2.08	0.83	0.41
Lsd		7.69	5.44	5.44	7.19	6.08	7.19	6.08	8.59	5.44	9.41	5.44	5.44	5.435	3.84	2.71
Cv		8.98	6.59	5.92	10.18	8.33	9.26	10.75	16.35	9.62	26.66	16.49	15.75	21.08	16.4	12.0

[a]Means followed by same letters in column are not significantly different at 5% probability level; variety ([1]Mwitemania, [2]Katumani, [3]Kathika), pathogen ([4]Rhizoctonia, [5]Pythium, [6]Fusarium, [7]Macrophomina), [8]Cattle Manure Vermicompost.

V. DISCUSSION

The findings revealed that there was a significant effect of CMV on the severity of root rot in beans in the greenhouse pot experiments. In the greenhouse pot experiments, adding CMV made the root rot disease caused by *Fusarium solani*, *Macrophomina phaseolina*, *Pythium aphanidermatum, and Rhizoctonia solani* much less severe. Vermicomposts contain coelomic fluid and other bioactive substances secreted by earthworms, which suppress diseases [11]. In addition, vermicomposts contain a wide range of beneficial microbes that inhibit root rot-causing pathogens in the soil [10, 11]. The findings are in harmony with previous research results, which showed the application of vermicomposts reduced root rot diseases in beans [1]. Additionally, the results are in line with what other studies have found: vermicompost can stop soil-borne and leaf diseases in plants [12, 13, 14]. On the other hand, the disease severity index of root rot disease decreased with an increase in the concentration of the CMV amendments. The highest severity of root rot disease was recorded in soils without CMV (0%) amendments. Pots with soil amended with 40% vermicompost recorded the lowest disease severity index range between 0 to 3.3. [Table 3]. This implies that an increase in the concentration of CMV increased the amount of beneficial microbes and suppressive substances in the soil, hence inhibiting pathogenic growth and sporulation. These results align with previous study findings, which showed that amendment of vermicompost at 30-40% by volume significantly suppressed plant diseases [11].

VI. Conclusion

The study findings showed that CMV significantly reduced the severity root rot disease in bean plants during use pot experiments ($p < 0.05$). The maximum suppression effect (lowest severity index of root rot disease between 0 and 3.3) was observed at 40% amendment of CMV. Therefore, the cattle manure vermicomposts should be used for the management of root rot disease in bean production.

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