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Original Paper

Integrated Management of Black Pod (*Phytophthora palmivora*) Disease of Cocoa Through Fungicides and Cultural Practices in Southwestern Ethiopia

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Abstract*—Black pod disease of cocoa (Theobroma cacao L.) caused by Phytophthora palmivora is the major constraint in cocoa production in southwestern Ethiopia. Therefore, integrated field management trials were conducted to evaluate the efficacy of different fungicides against a disease epidemic of cocoa black pod in southwestern Ethiopia. The field experiment was laid out in a randomized complete block design with seven treatments and three replications. The experiment was performed during the 2021 and 2022 main cropping seasons using five fungicides: Copper oxychloride (Koka blue 50 WG) combined with cultural practices, Agro-laxyl 63.5 WP (Metalaxyl + Mancozeb) combined with cultural practices, Progress 250 EC (Propiconazole 25%) combined with cultural practices, Ethiozeb 80% WP (Mancozeb) combined with cultural practices, More 720 WP (Mancozeb +Cymoxanil) combined with cultural practices, cultural practices alone and control without any cultural practices and fungicides spray for control of black pod infection. Cultural practices such as nutrient management, pruning, plant and field hygiene etc. were implemented in all treatments except control. The results of the experiment indicated that copper oxychloride (Koka blue 50 WG) combined with cultural practices significantly affected the cocoa black pod epidemics. When paired with cultural practices, copper oxychloride (Koka blue 50 WG) had a considerably greater impact on lowering disease severity (4.76) than the other treatments. Additionally, compared to control plots, the incidence of disease was reduced by more than 50% when cultural practices alone were used. This shows that in farms where black pod disease severity is low, the disease may be economically managed by implementing cultural measures alone. So, the the study's findings, black pod disease can be controlled in areas with a high disease incidence by combining the application of copper oxychloride (Koka blue 50 WG) with other cultural practices.

Keywords*— Black pod, Cocoa, Cultural practices, Fungicides, Integrated

I. Introduction

A food-industrial crop primarily employed in the chocolate industry, cocoa played a vital part in eradicating poverty in the humid tropics' depressed areas. Smallholder farmers cultivate more than 90% of the total cocoa produced in the globe [9, 11]. About 5 to 6 million farmers primarily from Africa, Asia, Latin America, and Oceania are thought to produce cocoa. According to [4], the top six producers of cocoa are Côte d'Ivoire, Ghana, Indonesia, Nigeria, Cameroon, and Brazil. The correctly fermented and dried seed or beans are the crop's most valuable component. The cocoa-chocolate value chain generates billions of dollars, providing significant shares for producing nations as well as for local and global businesses.

Southwest Ethiopia, specifically Tepi, Bebeka, Gemadiro, etc., is where cocoa is primarily grown in Ethiopia. The shady conditions in farming systems combined with the suitable summer weather conditions favor the growth and spread of Phytophthora infections. The cocoa black pod, which can result in major pod losses of up to 30% and the yearly death of up to 10% of trees, is a serious economic issue in all cocoa-growing regions of the world [5]. Black pod, a damaging disease caused by Phytophthora palmivora, is the most common and prevalent cocoa disease in Ethiopia [12]. In southwestern Ethiopia, the disease is becoming more common and severe. According to reports, fungicidal spray could only partially prevent this disease since strong rains washed the fungicides off the surface of the plants [6]. To date, no attempt has been made in Ethiopia to create integrated disease management strategies using fungicides and cultural practices to treat the disease. Given the significance of black pod disease, this study is designed with the following objectives: to develop fungicides and cultural approaches that will effectively manage cocoa black pod disease.

II. Material And Methods

A. Experimental material and treatments

At the Tepi Agricultural Research Center during the main cropping seasons of 2021 and 2022, a field experiment was conducted. Due to the location being a disease hotspot, the experiment depended solely on natural black pod epidemics. These regions have a long history of experiencing a lot of Phytophthora diseases that affect cocoa. Based on the laboratory analysis of samples taken from the affected fields, the cause organism of black pod disease in the area was found to be *Phytophthora palmivora*.

The experiment was set up using a randomized complete blocks design with five different fungicides combined with

cultural practices as treatments, one control treatment without the application of cultural practices, and three replications. One plant per replication served as the plot for each of the seven treatments. Copper oxychloride (Koka blue 50 WG) + Cultural practices, Agro-laxyl 63.5 WP (Metalaxyl + Mancozeb), Progress 250 EC (Propiconazole 25%), Ethiozeb 80% WP (Mancozeb), More 720 WP (Mancozeb +Cymoxanil), Cultural practices alone, and Control without any cultural practices or fungicide spray were the treatments. According to Chandra Mohanan et al. (2013), all fungicides were applied on the pods, main stem, and branches. Fungicide treatments were applied at intervals of fifteen days beginning with the appearance of black pod symptoms on cocoa pods. When cultural practices are used, they can help to reduce a disease spread and, if they are done right, can help control it. Pruning, mulching, plant and field cleanliness, shade and canopy management, weed control, frequent and thorough harvesting of cocoa pods, sanitation of diseased pods, and other recommended cultivation procedures were implemented in all treatments except for control.

B. Disease Assessments

Black pod disease incidence was recorded by counting the total number of pods and number of pods with disease incidence at an interval of 15 days and from the data, monthly percent disease incidence was calculated.

C. Data Analysis

In order to determine how treatments affected disease incidence, analysis of variance was conducted. Mean separation was calculated using the least significant difference (LSD) at the 5% level of confidence. [10] Statistical Analysis System (SAS) Version 9.3 was used for all data analysis.

III. Results and Discussion

Interaction effect of fungicides spray with cultural practices on black disease incidence showed highly significant ($P<0.01$) difference (Table 1). Field management tests conducted to combat black pod disease showed that copper oxychloride treatment coupled with cultural practices outperformed other treatments. Plots that were not sprayed and did not include cultural practices had the highest disease incidence (33.86%), followed by plots that only included cultural practices (15.39% at the time of the disease assessments). While the lowest (4.76%) level of disease incidence was found in plots sprayed with copper oxychloride (Koka blue 50 WG) in combination with cultural practices, it was followed by plots sprayed with Progress 250 EC (Propiconazole 25%) in combination with cultural practices (7.41%). In agreement with this finding, [1] found that Phytophtora pod rot could be effectively controlled by four-weekly spraying of either metalaxyl + copper-1-oxide (Ridomil 72 plus) or copper oxide (Nordox 75), along with to cultural practices.

The experiment's findings not only demonstrated the efficiency of fungicides in treating black pod disease when used together with cultural practices, but also clearly showed the value of adopting cultural practices for managing black pod disease. Compared to control plots, the incidence of disease was significantly lower when cultural practices alone were used. The mean disease incidence of this treatment also showed that black pod disease was reduced by more than 50% compared to control. According to [7], the removal of sick pods helped lower the incidence of black pod disease in Cameroon by 22–31% and 9–11% in the first and second years, respectively. Removal of mistletoe, excessive shade, basal chupons, diseased and mummified pods, and pruning of interconnecting branches were all suggested as critical components of the management of black pods in Ghana [1]. Additionally, [8] discovered that applying fungicides together with crop sanitation practices allowed for the effective management of black pod caused by P. megakarya, in comparison to fungicides application alone.

TABLE I. Fungicide use and cultural practices during the main cropping season of 2021/2022, and their effects on the occurrence of cocoa black pod disease at Tepi, Ethiopia.

Treatments	Disease incidence (%)	% Reduction over control
Copper oxychloride (koka blue 50 WG) + Cultural practices	4.76^{d}	86.11
Agro-laxyl 63.5 WP (Metalaxyl + Mancozeb) + Cultural practices	7.90^{cd}	76.66
Progress 250 EC (Propiconazole 25%) + Cultural practices	7.41^{cd}	78.11
Ethiozeb 80% WP (mancozeb) + Cultural practices	9.27^{cd}	72.62
More 720 WP (Mancozeb + Cymoxanil) + Cultural Practices	11.31^{bc}	66.59
Cultural practices alone	15.39^{b}	54.54
Control	33.86^{a}	-
LSD (5%)	5.75	
CV (%)	12.16	

Means followed by same letter(s) within a column are not significantly different at 5% level of significance

Black pod disease was also effectively reduced by Progress 250 EC (Propiconazole 25%) treatment together with cultural practices. The mean disease incidence showed that, compared to control plots, plots treated with Progress 250 EC

(propiconazole 25%) paired with cultural practices had a significantly lower incidence of black pod. Field tests also showed that the disease may be economically managed in gardens with lower black pod disease incidence using only the suggested cultural approaches. Therefore, the degree of disease severity and loss determines whether chemical fungicides are necessary to manage Phytophthora pod rot disease. On farms with very low yields, fungicide application could not be profitable. The study clearly revealed that in gardens with higher disease prevalence, black pod could be managed successfully when fungicide use is combined with cultural techniques. The greatest approach to the effective and long-term control of black pod disease appears to be to fully integrate Phytophthora disease management strategies into overall farm management.

IV. Conclusion

In Southwestern Ethiopia, one of the biggest constraint to the production of cocoa is the cocoa black pod disease caused by Phytophthora palmivora. Fungicide use lowers the occurrence of black epidemics. However, the application of an integrated disease management approach is necessary for the disease to be effectively managed. Chemical control is the most effective strategy, and Phytophthora palmivora can be controlled using fungicide applications that weaken or eradicate the pathogen during the crop cycle. As a result, it is advised for the management of cocoa black pod disease to use copper oxychloride (Koka blue 50 WG) sprayed in combination with cultural practices to significantly lower the parameters of cocoa black pod. It has been discovered that fungicide spraying when combined with cultural practices greatly lowers disease incidence and raises cocoa productivity by minimizing disease effects. Therefore, applying foliar fungicide sprays in addition to cultural control to address cocoa black pod disease in southwest Ethiopia appears promising.

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