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Full Length Research Paper

Management of black pod disease of cocoa with reduced number of fungicide application and crop sanitation

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Black pod disease caused by *Phytophthora megakarya* is the most important fungal disease on cocoa in Ghana. The current recommended control method of combining sanitation practices with 6 - 8 fungicide applications in a year is considered unfriendly to the environment, too expensive and time consuming. Consequently, fungicide adoption rate by farmers is extremely low. Studies were therefore conducted to determine the effectiveness of combining 1 - 3 fungicide application in June and/or September/October with crop sanitation for the control of cocoa black pod disease caused by *P. megakarya*. Sanitation practices were common to all the treatments and the fungicide application(s) superimposed. A semi-systemic fungicide, Ridomil 72 plus (12% metalaxyl + 60% copper-1-oxide), was used as the test fungicide. Fungicide application combined with crop sanitation practices were effective in the management of the severe form of black pod disease caused by *P. megakarya*, resulting in 25% to 48% disease reduction and 10.9% to 51.8% yield increase. Combining the sanitation practices with three fungicide applications gave significantly better results, in terms of disease control and yields than either sanitation practices alone or combining them with one or two fungicide applications. However, the combination of sanitation practices and three fungicide applications was significantly less effective than the standard fungicide application of six times a year. All the fungicide applications and/or crop sanitation practices were profitable with a Benefit Cost Ratio (BCR) ranging from 1.8 - 2.1.

Keywords: Cocoa, fungicides, sanitation practices, black pod, benefit cost ratio, *Phytophthora megakarya*

INTRODUCTION

Cocoa is the most lucrative cash crop in Ghana but the advent of the black pod disease caused by *Phytophthora megakarya* has substantially reduced farmers' revenue. *P. megakarya* black pod is the single most important fungal disease of cocoa in Ghana and some farmers have described it as a strange disease (Opoku et al., 2000), apparently because of the extreme virulence and the heavy losses associated with the pathogen. Pod losses ranging from 60 to 100% have been reported (Dakwa, 1987; Luterbacher and Akrofi, 1993; Opoku et al., 2000) and consequently, some cocoa farms have been neglected or abandoned. Other farmers have switched over to the cultivation of other crops (Anonymous, 1995; Opoku et al., 2000).

In spite of the devastating effects of *P. megakarya*, the adoption rate of its recommended control measure, that is, 6 - 8 times application of fungicides at 3 - 4 weekly intervals per season is very low. Surveys have shown that over 75% of farmers in Ghana do not control the black pod disease at all while about 2 - 3% spray between one and two times in a season (Henderson et al., 1992; Anonymous, 1995; Opoku et al., 1999). Interactions with farmers suggested three main reasons for the low adoption rate: high cost of treatment, high number of fungicide applications per season and laborious nature of the application.

In Ghana, it is known that the primary infections usually occur around June, but the peak of the *P. megakarya* black pod disease generally occurs between August and October (Opoku et al., 1999, 2000). Indeed, critical observations in the field have shown that in a typical season, very little of the black pod disease is seen until

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Table 1. The effect of different fungicide application regimes on black pod disease incidence and yield of cocoa.

Treatments[1]	Fermentable pods	Total Black pods	% D. I.	Estimated yield (kg/ha)
Single Fungicide application (June)	1613 e	682 b	45.3 b	768.1 d
Single Fungicide application (September)	1720 d	699 b	40.6 bc	819.0 d
Two Fungicide applications (September &October)	1866 c	686 b	36.8 cd	888.6 c
Three Fungicide applications(June, September & October)	2008 b	625 c	31.1 d	956.2 b
Standard Fungicide Application (control 1)	2209 a	518 d	19.0 e	1051.5 a
Sanitation practices alone (control 2)	1455 f	887 a	60.1 a	692.9 e
Mean	1795.2	691.2	40.1	854.8
LSD (0.05)	95.8	21.2	7.8	65.8

[1] = Sanitation practices were common to all treatments

August. Therefore, if resources could only permit a limited number of fungicide application, the farmers need to know the optimum number and the critical time to apply these resources. These studies were therefore conducted to determine the effectiveness of combining limited number of fungicide application with good crop sanitation practices, such as clean weeding, pruning and thinning, for the control of *P. megakarya* black pod disease.

MATERIALS AND METHODS

The studies were conducted at Bechem (latitude 7.12^{o}N and longitude 2.0^{o}N) in the Brong Ahafo Region of Ghana (a predominantly *P. megakarya* endemic area) for three crop seasons, between 2002 and 2005. The test trees were mixed Amazons and Amazon x Amelonado of 15 years old. Shade on all the plots was reduced to approximately 10 overhead trees *per* hectare in the first season. Sanitation practices such as clean weeding, pruning, thinning, were carried out in all plots from April to May, in addition to fortnightly removal of diseased and mummified pods throughout the study period. Fungicide application, which started in June and ended in October, was superimposed on all the treatments except the untreated control.

The following treatments were assessed: i) single fungicide application (SFA) in June plus the sanitation practices, ii) SFA in September plus the sanitation practices, iii) double fungicide application (DFA) in September and October plus the sanitation practices, iv) triple fungicide application (TFA) in June, September and October plus the sanitation practices, v) the standard fungicide application (StFA) at 4-weekly interval (six fungicide applications) from June to October with the sanitation practices and vi) the sanitation practices alone (SPA) as untreated control. Each treatment was applied on a plot of 30 trees and was replicated five times in a randomized complete block design. The test fungicide was Ridomil 72 plus (12% metalaxyl and 60% copper-1-oxide *ai*, Syngenta, Switzerland) and it was sprayed at a rate of 3.3 g/l, using a pneumatic spraying machine (Technoma T15, Eperney, France). Spraying was done up to the reach of the extension lance (approximately 3.5 m from the ground level).

Harvesting of pods was done at monthly intervals from August to February in each season. At each harvest, the pods were categorised as either healthy ripe pod (HRP) if the pod was completely free from the black pod disease, fermentable or useable black pod (FBP) if pod is diseased but of commercial value, or non-fermentable black pod (NFBP) if pod is diseased and of no commercial value. The total fermentable pods (TFP = HRP+FBP), total black pods (TBP = FBP+NFBP), total pods (TP = HRP + FBP+NFBP) and the percent disease incidence (%DI = TBP ÷ TP x 100) were then calculated. Taking 28 pods as the equivalent of 1 kg of dry beans (Lockwood and Edward, 1980) the yield per hectare was estimated.

Analysis of variance (ANOVA) was performed on the fermentable and total black pods after log transformation while the % DI data were analysed after arcsin transformation. Data sets showing significant differences were subjected to the test of Least Significant Difference at 95% confidence interval to determine which of the means were different.

Profitability, expressed as Benefit Cost Ratio (BCR), was calculated by partial budget analysis and taking into consideration labour requirement and yield (Soberanis et al., 1999).

RESULTS AND DISCUSSION

The trial results for yield and disease incidence of the three years' average are presented in Table 1. Apart from the standard fungicide application (StFA), the TFA combined with sanitation practices were the most effective in the management of *P. megakarya* black pod. The level of disease incidence on the TFA plots were significantly lower than that on the unsprayed control plots, as well as the single and double fungicide applications but was significantly greater than the StFA. However, no significant differences were found between the SFA in either June or September in terms of disease incidence, but both treatments were significantly better than the SPA. Similarly, TFA combined with sanitation practices had significantly smaller number of total black pods than the SFA in June and September and the DFA, but significantly greater number than the StFA. All the fungicide treatments had significantly smaller number of total black pods than the unsprayed control.

The need to control cocoa black pod disease by fungicide application depends on the anticipated magnitude of attack and loss of crop (Muller, 1974) as well as the resulting yield (Asare-Nyako, 1974), all of which must be high to justify the cost of treatment (McGgregor, 1882;

Table 2. Operational cost and revenue from crop sanitation practices and different fungicide application regimes.

Treatments	Production cost ($ha^{-1}yr^{-1}$)	Gross returns ($ha^{-1}yr^{-1}$)	Net returns ($ha^{-1}yr^{-1}$)	Benefit cost ratio[2]
Single Fungicide application (June)	398.5 d	753.9 d	355.4 c	1.9
Single Fungicide application (September)	398.5 d	803.8 d	405.3 b	2.0
Two Fungicide applications (September &October)	419.2 c	872.1 c	452.9 a	2.1
Three Fungicide applications (June, September & October)	459.9 b	938.5 b	478.6 a	2.0
Standard Fungicide Application (control 1)	582.0 a	1032.0 a	450.0 a	1.8
Sanitation practices alone (control 2)	357.8 e	680.1 e	342.3 c	1.9
Mean	425.7	846.7	414.1	
LSD (0.05)	18.9	58.6	35.6	

[2]=BCR is the Benefit Cost Ratio defined as the ratio of the returns accrued in relation to the cost incurred in applying the treatment. BCR of 1 is break even, greater than 1 is considered profitable and less than 1 is a loss. Average annual price of cocoa beans/kg = ¢8,833.33 ($0.98).

Thorold, 1967). Such high levels of pod attack and loss of crop, as well as the benefits of embarking on the StFA, are known to be associated with *P. megakarya* black pod in Ghana (Akrofi et al., 2002; Opoku et al., 2000, 2004). Sanitation practices are the least expensive disease control option and should be the preferred tool provided they are effective in the locality. In the present study where diseased pods were removed fortnightly, the disease incidence on plots treated with crop sanitation practices alone was 60%. The incidence was 45.3% when the sanitation practices were combined with SFA in June, dropping by 24.6%. It dropped by 32.4% when the practices were combined with SFA in September, 38.8% when combined with DFA in September and October and 48.3% when combined with TFA in June, September and October. This is a clear demonstration that crop sanitation practices alone were not adequate for the control of black pod disease caused by *P. megakarya*. Similar results were reported in Cameroon where pod losses caused by *P. megakarya* were reduced from 35% to about 1% by combining sanitation practices with fungicide application (Ventilborgh, 1987). After an initial infection, the subsequent spread of *P. magakarya* depends, to a large extent, on the level of spore production and dissemination. Prophylactic measures of black pod disease control, including the removal of diseased pods at frequent intervals, ensure that the amount of disease inoculum and pressure, and conse-quently disease incidence, are kept low. *P. magakarya*, unlike other *Phytophthoras* on cocoa, is more prolific and more aggressive and is effectively managed by combin-ing crop sanitation practices with fungicide application but not with either practice alone (Opoku et al., 2000). Earlier studies showed that removal of diseased pods at 10-day intervals is more effective (Dakwa et al., 1988) but probably uneconomical. It must however, be emphasized that the current studies were Researcher managed and were therefore possible to follow strict sanitation practices. Considerable efforts will be required to educate the Ghanaian peasant farmer to adopt such strict sanitation practices so as to obtain the results as reported here. The choice of fungicide is also important in such an extended application (Akrofi et al., 2002). Ridomil 72 plus used in this trial is a semi-systemic and more persistent than contact fungicides.

The number of fermentable pods and consequently the estimated yield followed a trend similar to the percent disease incidence. All fungicide/sanitation combinations produced significantly better yields than the crop sanitation practices alone, resulting in yield increases of between 10.9 and 51.8%. However, yields from the TFA were significantly higher than either the SFA or the DFA but significantly lower than the standard control. The significantly higher number of fermentable pods on the fungicide/sanitation treatments suggests some degree of suppression of fungal activity on the pod. On several infected pods, it was observed that disease lesions were localized and failed to expand. In fact, more localized lesions were evident on pods treated with TFA than the DFA, the SFA and the SPA. Consequently, yields from SFA in June and September were not significantly different from each other, but yields from the TFA plots exceeded those of the DFA by 7.6%, the SFA in June by 24.5%, SFA in September by 16.8% and the SPA by 38%, but were lower than those of the StFA by 9.1%. However, in spite of the slightly lower efficacy of the TFA compared with the StFA, the former could be combined with sanitation practices to effectively manage the black pod disease and sustain cocoa production in *P. megakarya* endemic areas in Ghana. Farmers are more likely to accept a limited number of three applications than the current recommendation of 6 - 8 applications per year. Such a system will not only cost the farmer less money compared to the StFA, but will also mean less pollution of the environment with fungicides. Its success will however, depend in part on sound educational programmes, farmer training and sensitization.

Compared with the SPA, operational cost increased by $40.7 for every additional fungicide application (Table 2). However, the increase in gross revenue compensated for

the increase in expenditure. Net revenue increased from $342.3 with the SPA to $452.9 with the DFA and $ 478.6 in case of the TFA. Thus, the SFA in September, DFA, TFA and StFA were 18.4, 32.3, 39.8 and 31.5% respectively, more profitable than the SPA. However, the net revenue for the DFA, TFA and the StFA were not significantly different from one another. Whether alone or in combination with sanitation practices, fungicide application was profitable with a Benefit Cost Ratio ranging from 1.8 for the StFA to 2.1 for the DFA. Although these trials were conducted on a small scale, the economic benefits were quite substantial. Therefore, considering the economics of scale, profits are likely to be greater when larger plots are used (Henderson et al, 1992). Currently, the TFA and crop sanitation, have been used in a nationwide black pod control programme with remarkable success (Opoku et al., in press).

The use of pesticide and its associated potential damage to the environment are a concern for all and efforts must be made to reduce pesticide usage. Pesticides must be applied only when necessary, and with a great deal of caution. From the results, it is obvious that strict crop sanitation practices combined with three fungicide applications in June, September and October is an effective way to manage the severe form of the black pod disease in Ghana though the treatment is not as effective as the standard method of control. This recommendation is particularly intended for peasant farmers with smallholdings who cannot afford the high cost of the current recommendation of 6 - 8 fungicide applications per season.

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