The chemical control of *Phytophthora* pod rot in Nigeria. An evaluation of the present situation

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INTRODUCTION

Black-pod disease of cocoa caused by the fungus *Phytophthora palmivora* (Butl.) Butl. occurs in most cocoa producing areas of the world. The recorded occurrences of this disease are virtually co-extensive with the cultivation of *Theobroma cacao*. This fungus is also frequently associated with other serious cocoa diseases ranging from canker to wilt and die-back affecting branches or whole trees. The ubiquity of this fungus as a cocoa pathogen is equalled only by that of *Botryodiplodia theobromae*, a less virulent parasite associated with the disease commonly referred to as the 'brown pod' rot.

Economic losses due to *Phytophthora* pod rot disease in Nigeria is very difficult to estimate in view of the fact that severity of the disease varies from year to year and from area to area. Various estimates (JOHN and GIBBERD, 1951 ; ANON, 1954) indicated that about 12.5 to 25 percent of dry cocoa beans are lost annually in Nigeria. However, the recent estimation is that losses may be up to 30 to 35 percent of the total cocoa crop (GORENZ and OKAISABOR, 1971). The continuation, therefore, of profitable cocoa growing in Nigeria requires a good control of this pod disease.

HISTORICAL BACKGROUND

THOROLD (1953) reported that a rational approach to the problem of controlling black-pod may be said to have started with RORER's studies on the life history of *Phytophthora palmivora*. RORER was also reported to have advocated chemical spraying and considered that at least four applications should be given during the wet season. LAYCOCK began spraying experiments in Nigeria, and these were continued by WEST (1936) who found that spraying three times a year was uneconomic. The sound foundation for the control of this disease by chemical spray can be said to have been laid by THOROLD (1953) who sited his experiments at Owena in Western Nigeria where he found that frequent applications of copper fungicides to pods he found that frequent applications of copper fungicides to pods in the wet season reduced the incidence of the disease. He also showed that the onset and intensity of black-pod disease in cocoa is correlated with rainfall and high humidity. THOROLD (1959) also concluded that under certain specific conditions of crop size, economic control of the disease can be obtained by the application to pods of either cuprous oxide formulations or Carbide Bordeaux mixture at three-weekly intervals.

The work of THOROLD was continued by HISLOP and PARK (1962 a, b, c) who started laboratory bioassays on detached green pods before testing on the field. They tested and compared various formulations of copper including Bordeaux Mixture (copper sulphate), cuprous oxide and copper oxychloride under field conditions. These workers were able to establish a very strong positive correlation between the results of the laboratory and field tests. It was, however, generally agreed that Bordeaux mixture gave the best protection even though cuprous oxide may be preferable on account of easier preparation and suitability for low application by mist-blowing.

THE CURRENT SITUATION

The involvement of the Cocoa Research Institute of Nigeria (CRIN) in the chemical control of *Phytophthora* pod rot can be said to have started with the work of HISLOP (1962 a, b, c) who was a Plant Pathologist in the defunct West African Cocoa Research Institute (WACRI). It was not until 1965 that very extensive research work was started on testing fungicides. It is also pertinent to point out that it was not until that year that fungicides based on active ingredients other than copper were tested against *P. palmivora*. (See Table I.)

It is a matter of routine policy that laboratory screening tests are carried out to determine those formulations which are promising enough to be subjected to field tests. This procedure reduces the cost, labour and time involved in carrying these field tests. Methods that have been used in the past included mixed culture methods where the fungicide and the test organism are brought into intimate contact in single medium — on an agar plate, or in water droplet on a microscope slide. The method that has been extensively used in our laboratory is that in which green healthy cocoa pods are tied at their stalks into cages made of brass welding rods. These are then

TABLE I

SUMMARY OF SOME SPRAY EXPERIMENTS IN NIGERIA
(pods sprayed every 3 weeks using pressurised knapsack pumps)

Year	Location	Worker	Treatments (percentage black-pod)						
			Control	Bordeaux mixture	Tri-phenyltin acet.	CuO_2	Triphenyl tion -OH	Difolatan	$Cu(OH)_2$
April 1962	Aponmu	THOROLD	75	6	—	—			
May 1956	»	»	49-64	16		10			
May 1960	Gambari (CRIN)	HISLOP	62-78	36		43			
June 1961	»	»	45	21	19				
May 1962	»	»	57	31	41 (.04) *				
July 1965	»	WESTSTEIJN & FILANI	47	36	26 (0.10)			33	
July 1965	Ibule	»	51	22	29 (.10)			41	
June 1966	Gambari (CRIN)	WESTSTEIJN	47	20	28 (.06)		20 (.06)		
	Ibule	»	67	26	27 (.06)		33 (.06)		
June 1967	Gambari (CRIN)	GOREN	43	27	21 (.09)		17 (.09)		
	Ibule	»	79	52	48 (.09)		33 (.09)		
July 1968	Gambari (CRIN)	»	29	30	24 (2.7)	37			22-28
	Ibule	»	82	77	70 (2.7)	85			
May 1969	Gambari (CRIN)	»	34-38	21	24 (.09)	25			18
	Ibule	»	85-91	76	85 (.09)	80-87			85
June 1970	Gambari (CRIN)	»	35	35	36 (.09)	35	47 (.09)	29	14
	Ibule	»	92	82	82 (.09)	82	82 (.09)	90	84
	Uhonmora	»	40	18					

* Figures in brackets indicate the percentage active ingredient (GOREN & OKAISABOR, 1970).

sprayed with standard Bordeaux mixture or any other fungicide under test and then allowed to dry before being sprayed again with an aqueous zoospore suspension after which the pods are placed in polythene bags and then incubated in an air-conditioned room (20°-25° C). The number of lesions developed on each pod is then counted four and six days later (HISLOP and PARK 1962 a). Many different fungicides have been tested but the most successful ones are those based on copper (OKAISABOR 1971). It is very remarkable that of all the fungicides yet tested Bordeaux Mixture has not been displaced as the best since its discovery by MILLARDET in 1882. In fairness, however, others, particularly the Triphenyl Tin compounds, are showing some promises.

Although copper has been found to be highly fungicidal and inhibitory to zoospore germination and fungal growth (MARTIN 1968; OKAISABOR 1970; FILANI, *in press*) under laboratory conditions, the performance under field conditions has been most unsatisfactory because of the very low level of control achieved. The average annual loss due to *Phytophthora* pod rot disease is high in certain parts of Nigeria particularly in the cocoa producing areas of the South Eastern State where it rains almost all the year round with an annual rainfall of 120 inches. It is indeed the general opinion that any fungicide which succeeds in controlling the disease in this area is likely to be successful anywhere in the cocoa belt of Nigeria.

There are various factors or a combination of factors that may be responsible for the relatively low level of control of black-pod disease achieved in the field. One of the most important factors limiting the effectiveness of any agricultural chemical is the method and efficiency of application. The most potent chemical would be least effective if it is not properly applied. It has been established that pod coverage by fungicide is very poor in many cases. GORENZ (1971) estimated that under field conditions, less than 10 percent of the spray mixture remain on the pod surfaces. FILANI *(in press)* also observed that in many cases pod coverage was so poor that it was impossible to determine chemically the amount of copper deposited on the pods. These observations could be as a result of any or a combination of the following :

(*a*) Improper application of the fungicide suspension by the sprayers. It is common knowledge that by the very nature of Bordeaux mixture the suspension settles very quickly in the tank, and this is why it is advised that the pump be agitated occasionally to avoid spraying only the supernatant into the pods thus leading to a better established pathogen. In many cases the lances are too short resulting in the pods located high above the tree being left unsprayed. This is particularly important in the older plots of Amelonado trees which are averagely over 10 feet high.

(*b*) Weathering particularly the washing off effects of the rain is one of the major important factors that affect the effectiveness of Bordeaux mixture (HISLOP and PARK 1962 b). Generally this disease is more serious in the high rainfall areas of South Eastern Nigeria, than in the drier cocoa areas around Egbado Division in the South-West. Efforts are being made to improve the performance of existing fungicides by the incorporation of stickers and spreaders. GORENZ (1971) showed that the use of very high lime (10:10:100) in place of the standard (10:4:10) Bordeaux mixture resulted in better tenacity against washing off, better coverage, easier check for proper spraying and therefore a higher level of control. Also the chemical manufacturers are coming up with more 'stable' compounds which are said to possess better retentive properties. In addition, research is in progress on oil-based fungicides for the high rainfall areas.

Another important factor which is unknown, and which might influence the effectiveness of Bordeaux mixture is whether *P. palmivora* is exhibiting any form of tolerance or resistance to copper. Although as at present, there are no data to suggest that there is resistance, however, be entirely ruled out. For example in East Africa copper spray has been found to result in more abundant pathogenic strains of *Colletotrichum coffeanum*, the causal agent of Coffee Berry Disease (FURTADO 1969). In order to establish this fact for *P. palmivora*, samples of this pathogen are now being collected from all over the cocoa belts in Nigeria and their degree of tolerance to copper is being determined.

A LOOK AT THE FUTURE

So far in Nigeria, almost all the efforts put into the control of *Phytophthora* pod rot has been directed at the cocoa pod -- i.e. spraying the pods directly with the chemical. In recent years, however, some attempts have been made at attacking the fungus at other locations other than the pod on the trees.

Results of epidemiological studies have shown that at least a phase of the life cycle of *P. palmivora* occurs in the soil and that the later constitutes a reservoir of inoculum. The survival of the fungus in the soil in the dry season was reported by TURNER (1959) and the ability of the fungus to pereniate in heaps of diseased pods was demonstrated by THOROLD (1955), and many other workers. In Nigeria soil-borne inoculum appears to be primarily responsible for fresh outbreaks of the disease especially during the first couple of months of the epiphytotics. Efforts have been made to study the various aspects of the soil phase of the fungus and to establish the layer of the soil profile in which it occurs most abundantly and it has been found that the pathogen survives mainly in the upper layers of the soil and in the centre of old heaps of diseased pods. Recent studies have also shown that the fungus may freely produce oospores and resistant structures in the soil, especially in the root zone of cocoa trees (OKAISABOR 1969 a, c). In view of this increasing importance being attached to the soil as a source of inoculum of *P. palmivora* the use of soil fungicides in controlling the phases of its life cycle present in the soil has been initiated. Initial results (OKAISABOR 1970) have shown that there are some promising formulations.

Insects have been heavily implicated in the spread of the disease. DADE (1927) isolated *P. palmivora* together with other fungi from insects and suggested that tree to tree transmission is mainly due to insect movements. After this early observation the role of insects in the epidemiology of this disease was virtually neglected for many years until workers in Nigeria drew attention to this very important aspect of the disease. GORENZ (1968) implicated ants in the spread of *P. palmivora*, and this was confirmed by OKAISABOR (1969) who showed experimentally that some hymenopterous insects effectively transmitted the disease. The important role of insect transmission in the spread of this disease has also been confirmed in Ghana (EVANS 1971).

In view of this important role of insects in the epidemiology of this disease, studies have been carried out on the direct insecticidal controls of the insects and on the use of mixtures of insecticides and fungicides. WESTSTEIJN (1968) obtained a better level of control of black pod disease by spraying with mixture of Didimac 25 and Bordeaux mixture, and OKAISABOR (1971) obtained a higher level of control. It is also noteworthy here to mention that many Nigerian farmers generally apply mixtures of insecticide and fungicide when spraying against mirids and black-pod disease. This is done, not only to obtain a higher level of control, but also to save time and labour therefore a reduction in the cost of spraying (GALLETTI et al. 1956 ; WESTSTEIJN 1968), and this technique is becoming increasingly more popular amongst peasant farmers in Nigeria.

Cultural practices particularly simple sanitation processes have been shown to aid proper control of *P. palmivora*. The two most important factors enhancing the spread of this fungus are the environmental relative humidity and temperature. In Nigeria, the presence of *Phytophthora* pod rot disease in the field is confined to the rainy season. The high relative humidity associated with a well distributed rainfall is favourable for occurrence of the disease because the presence of moisture on cocoa trees from rain or dew is a condition for infection (THOROLD 1967 ; GORENZ and OKAISABOR 1971). In the wet tropics, including Nigeria the possible effects of low temperatures on black pod incidence may not be separable from humidity effect. THOROLD (1955) showed that low temperatures are associated with high relative humidities. Since these two factors are pre-requisite conditions for the spread of the disease, the removal of shade trees and weeds coupled with judicious pruning of cocoa trees will enhance ventilation of the farm thus resulting in reduced pod rot disease. These practices coupled with constant inspection and removal of black-pods, proper and timely chemical spraying would all result in a good and improved level of control.

CONCLUSION

The use of fungicides for the control of *Phytophthora* pod rot is an accepted standard practice among Nigerian cocoa farmers. Bordeaux Mixture (copper sulphate) is the standard fungicide recommended to the farmers, although Cocoa Research Institute of Nigeria is very actively engaged in the search for any other alternative formulations which are cheaper and easier to apply. Copper spray programme started in Nigeria on a large scale about twelve years ago when the fungicide subsidy scheme was started by the Western Nigeria Government at that time (Tella, 1970). As a result of the introduction of this subsidy scheme, fungicidal usage on cocoa has increased steadily resulting in a steady increase of the subsidy from about 400,000 in 1960 to just under 2 million in 1970. The total tonage of cocoa actually graded has almost doubled during this period and it is also pertinent to mention that for this period the quality of cocoa produced has greatly improved. Availability of cocoa fungicides at subsidized prices, and the ready acceptance of spraying as a matter of routine practice by the farmers must in no small measure have contributed to these increases in quality and quantity.

The long term solution to the problems of pod rot disease may therefore be found, apart from breeding resistant varieties, in improving the performances of the existing formulations, testing new fungicides, intensification of active research into oil-based fungicides particularly in the high — rainfall areas, and effective control of vectors of this elusive pathogen.

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