PROCEDURE FOR SCREENING “NEW FUNGICIDES” FOR THE CONTROL OF PHYTOPHTHORA POD ROT (BLACK POD) DISEASE OF COCOA IN GHANA

Technical Bulletin No. 27

A. Y. Akrofi, M. K. Assuah and I. Amoako-Attah
# CONTENTS

Forward

1. Introduction 1

2. Submission of new fungicides by Agro-chemical companies 4

3. Contractual Terms between CRIG and Agro-chemical Company before, during and after Screening 4

4. Laboratory Screening 7

5. Field Screening
   5.1. Small Scale Field trials (researcher-managed trials) 8
   5.2. Large scale field trials (on-farm researcher-farmer managed trials) 9

6. Assessment of efficacy of fungicide 10

7. Evaluation of field records 11

8. Residue analysis and taint tests 12


10. Further considerations 13
   10.1. Pricing 13
   10.2. Long term evaluation of recommended fungicides 13
   10.3 Annual renewal of certificates of recommended fungicides 13

11. Acknowledgment 14

12. Further Reading 14
Cocoa is a major source of income for rural families and plays a significant role in the agricultural sector of Ghana's economy. However, *Phytophthora* pod rot (black pod) disease remains a major constraint to sustainable cocoa production. Fungicides continue to be used in managing the disease in Ghana. The concern of consumers of cocoa products on pesticide residues and of environmentalists on continuous use of fungicides on the environment and the possible risk to farmers health is a matter of serious concern for health workers and to Ghana Cocoa Board (COCOBOD).

This bulletin on the procedure for screening “new fungicides” for the control of black pod disease of cocoa in Ghana is therefore timely. The bulletin, which outlines the current established procedure followed at the Plant Pathology Division of the Cocoa Research Institute of Ghana (CRIG) for screening “new” fungicides for black pod disease control in Ghana is to educate policy makers, agrochemical companies and their agents, extension personnel and farmers on fungicide screening at CRIG. It is based on a wide range research of best practices and protocols, drawing on current experience and that of past researchers.

It is anticipated that policy makers, agrochemical companies and/or their agents and agro-input dealers will find this bulletin useful on some of their concerns regarding fungicide screening for black pod disease control in Ghana. The bulletin will also serve as an assurance to cocoa farmers, consumers of cocoa products from Ghana and environmentalists of the exhaustive procedures any fungicide undergo before being approved and recommended for use on cocoa in Ghana. The bulletin is an invaluable addition to the list of CRIG's farmer-centered publications that will enhance the linkage between research and industry and improve the livelihoods of our farmers through increase in cocoa production.

Dr. Frank M. Amoah.

*Executive Director, CRIG.*
Phytophthora pod rot (black pod) disease of cocoa caused primarily by Phytophthora palmivora and P. megakarya is presently the most important fungal disease of the crop in Ghana. The disease is as old as cocoa cultivation in the country but losses of economic levels became evident since 1985, when P. megakarya was found in Ghana (Plate 1). Black pod disease is especially severe in moist humid environments and in Ghana it is usually prevalent between the rainy months of June and October.

Plate 1. P. megakarya infected cocoa tree (left panel) and healthy cocoa trees (right panel)
Phytophthora palmivora and P. megakarya belong to the large group of plant-damaging Oomycetes and they can infect every living tissue of the cocoa plant causing root rot, stem canker, leaf blight and pod rot. The Oomycetes belong to the Kingdom Stramenopiles (more commonly, CHROMISTA) or 'water fungi' due to their reliance on free water and high humidity for spore production, germination, dissemination (or movement) and infection. For this bulletin, P. palmivora and P. megakarya will be referred to as “fungi” and the products used for their control as “fungicides”.

Fungicides are widely used for controlling black pod disease in many black pod disease endemic countries in West Africa, and their impact on cocoa production has been extensively studied in Ghana. Fungicide use and the use of broad spectrum pesticides have public health and environmental implications. Many importing countries of cocoa and cocoa products have introduced maximum residue limits (MRLs) which is the cutoff point of pesticide levels allowable in cocoa beans and cocoa products. Japan, for instance, introduced a new legislation on MRLs in 2006 and the European Union (EU) has since September, 2008 legislated new MRLs (EC 148/2008). These MRLs are continuously being reviewed to meet consumers’ demand on food quality. These and other stringent quality control measures on pesticides required by cocoa importing countries means that efforts must be intensified to ensure strict compliance to good agricultural practices with respect to pesticide use on cocoa. Fortunately in Ghana, considerable advances have been made in black pod disease control to prevent undesirable pesticide residues and contamination of cocoa beans. This ensures that cocoa and cocoa
products from Ghana continue to meet international standards and maintain the country's position as number one producer of highest quality cocoa beans globally.

The Cocoa Research Institute of Ghana (CRIG) of Ghana Cocoa Board (COCOBOD) is the only Institute in the country mandated to screen and recommend pesticides for use on cocoa in Ghana. Before any pesticide is recommended, CRIG ensures that meticulous laboratory and field tests are carried out to generate sufficient data to support evidence of effectiveness of the pesticide, and also its safety to the farmer, the consumer of cocoa and its products and the environment.

This bulletin outlines the current established procedure followed at the Plant Pathology Division of CRIG for screening 'new' fungicides for black pod disease control in Ghana. We hope that agro-chemical companies and/or their agents will find this bulletin useful on some of their concerns regarding screening of fungicides for black pod disease control in Ghana. The bulletin will also serve as an assurance to cocoa farmers, consumers of cocoa products from Ghana and environmentalists of the exhaustive procedures any fungicide undergo before being approved and recommended for use on cocoa in Ghana.
Agro-chemical companies or their agents submit sample of their product with all the relevant material safety data (MSD) to CRIG through COCOBOD. The MSD must indicate the product name, active ingredients, formulation type, manufacturer, shelf-life and any other relevant information that will facilitate testing of the product. At CRIG, the sample is passed on to the Committee for Testing Chemicals and Machines (CTCM) that mandates Plant Pathology Division to test the product. The Division acknowledges receipt of the sample and informs the submitting company of the contractual terms for testing of the product.

Each “new fungicide” goes through three main stages of testing: laboratory, small scale and large scale field trials. Prior to these tests, CRIG requires the agro-chemical company or its agent to confirm that they have agreed to:

i. Pay laboratory screening fee.

ii. Pay field evaluation fee on annual basis for the whole testing period. Each payment obligation must be met in full before commencement of the screening.
iii. Supply adequate samples of the product on time and at no cost to CRIG for the entire testing period.
iv. Analysis of the sample to confirm the active ingredient(s) indicated at the expense of the Company or its agent.
v. Compensate farmers when crop losses occur due to the fungicide treatment.
vi. Provide unit cost of the product to facilitate economic analysis
vii. CRIG provides annual reports on the performance of the fungicide to the Agrochemical company or its agent

The new fungicide is evaluated \textit{in-vitro} against different propagules of the major black pod pathogens and on detached cocoa pods under laboratory conditions. Different concentrations of the fungicide (usually including the manufacturer’s recommendation) are tested in an appropriate experimental design with sufficient replications. Criteria including minimum concentration of the fungicide that will inhibit mycelia growth (Plates 2 and 3), rate of lesion development and degree of sporulation on detached pods (plates 4) are studied. In these tests, a standard (reference) fungicide and an untreated control are included for comparison.
Plate 2. Inhibition of mycelia growth of Phytophthora on Campbell Vegetable Juice Agar media (V8A) using the poisoned food technique 4 days after inoculation. A, B, C, D indicates effective fungicides with no mycelia growth while E indicates ineffective fungicide showing mycelial growth.

Plate 3. Effect of different concentrations of a test fungicide on mycelia growth of Phytophthora on V8A stored at 25°C for 5 days. Mycelia diameter (arrowed) increases with decrease in fungicide concentration.
Plate 4. Effect of test fungicides on Phytophthora lesion development and sporulation on four-month old detached cocoa pods (left panel) and on cherelles (right panel) four days after inoculation and incubated in a humid chamber at 28 ± 2°C. Note the different lesion sizes on the different fungicide treatments (T₁ and T₂) and no lesion on control pods and cherelles.

5.0 FIELD SCREENING

Laboratory tests are conducted under controlled conditions. These do not reflect field situation where disease development is influenced by the interplay of environmental factors (biotic and abiotic), the host and the pathogen. It is therefore essential that candidate fungicides that show fungicidal and or fungistatic action against the Phytophthora species are tested sufficiently in the field in appropriate experimental designs. At CRIG, small and large-scale field trials are routinely carried out. Spraying starts at the beginning of the rains (usually May or June) and when there are pods on the cocoa trees till the end of the rainy season (usually October or November). Only pods and cherelles within reach of the
extension lance of the spraying machine (up to about 3.5m from ground level) are sprayed. Spraying is done with well calibrated pneumatic spraying machine fitted with cone-shaped nozzle that ensure uniform spray droplets and total coverage of the pods (plate 5).

Plate 5. Cocoa trees sprayed with different test fungicides. Note different colours of fungicides on pods and trunk.

5.1 Small scale field trials (researcher-managed trials)

Fungicides which prove promising from the laboratory test are evaluated in small-scale researcher-managed field trials in both *P. palmivora* and *P. megakarya* endemic areas. Personnel from CRIG carry out the fungicide
spraying. Different concentrations of the fungicide are applied on standard number of cocoa trees. A recommended fungicide (standard) and an untreated control treatment are included for comparison. The test fungicide is evaluated for at least two (2) consecutive years to establish the most effective dosage and frequency of application. If consistent promising results are obtained over the two-year period, the fungicide is further evaluated on farmers' farms in large-scale trials using information generated in the small-scale trials. On the other hand, where results over the two-year period are not consistent, a third year evaluation on the small-scale is carried out to confirm the efficacy or otherwise of the product.

5.2. Large scale field trials (on-farm researcher-farmer managed trials)

Fungicide concentration which give the least disease incidence and the highest yield in the small-scale field trials is further evaluated in large scale trials (LST) and managed by researchers and farmers for at least two cocoa seasons. These trials are sited on farmers' farms in different agro-climatic conditions in all the cocoa growing regions. This ensures that recommendations made on the fungicide are valid for all cocoa growing regions in the country. The participating farmers apply the fungicides themselves with CRIG supervision. In the LST, a standard fungicide is included for comparison. Any information on the effect of the test fungicide on farmers and on the environment during and after application are documented.
The level of black pod disease on plots sprayed with the test fungicide is used to assess the efficacy of the fungicide. Disease assessment lasts for seven (7) months, beginning from August of the year of spraying until February the following year. Harvested pods are categorised into Healthy Ripe Pod (HRP, pods completely free from black pod disease); Usable Black Pod (UBP, diseased pods but of commercial value) and Non-Usable Black Pod (NUBP, diseased pods with no commercial value) (Plate 6). From these categorized data, total black pods (TBP), fermentable pods (FP), percent disease incidence (% DI) and yield are calculated. Additionally, at the small and the large scale trials, any harmful effect of the product on users, non-target organisms (invertebrates) and soil dwelling decomposers are assessed. Cost benefit analysis is conducted during the large scale trials. All data are analysed with appropriate statistical tools.

Plate 6. Categories of pods used in assessing efficacy of fungicides
Due diligence is paid to field data collection and analysis since they form the basis for approving or rejecting a fungicide. Disease incidence is an important criterion for differentiating between effective and ineffective products (Plate 7). Yield records also have special significance because the farmer is interested in crop protection. It must also be emphasized that a fungicide which meets all the above criteria but poses harmful effects to users or the environment is still not approved for use on cocoa in Ghana.

Plate 7. Cocoa trees sprayed with ineffective fungicide (left panel) and with effective fungicide (right panel).
8.0 RESIDUE ANALYSIS AND TAINT TESTS

During the field evaluation, residue analysis and taint tests of fermented and dried cocoa beans from plots sprayed with the test fungicide are carried out in reputable laboratories identified by CRIG. For a fungicide to be recommended, its residue in the cocoa bean should be below the maximum residue level (MRL) set by cocoa importing countries and also permissible by chocolate manufacturing companies. The test must also establish that the fungicide does not leave any taint on the cocoa beans.

9.0 PROCESS OF RECOMMENDATION

At the end of the trials, reports on the test fungicide are submitted to CRIG's Committee for Testing of Chemicals and Machines (CTCM) for critical examination of test procedures, results, analyses and conclusions drawn. A copy of each season's report is submitted to the agro-chemical company/agent through COCOBOD. Final report is submitted to COCOBOD for approval. Once approved, the fungicide is included in the list of fungicides recommended for use on cocoa in Ghana. Where a fungicide does not meet the approval criteria, a report on its performance over the evaluation period is also given to the agro-chemical company or its agent through the approved channel described above.
10 FURTHER CONSIDERATIONS

10.1. Pricing

During the large-scale trials, the agro-chemical company/agent is usually advised to consider the pricing of the product at the indicated rate of application. The indicative price should be communicated to CRIG during the large-scale on-farm trials to facilitate economic analysis of the product.

10.2. Long term evaluation of recommended fungicides

The effectiveness of the recommended fungicide and its cumulative effect on users and on the environment are continuously monitored after the product has been approved and recommended for use on cocoa. The monitoring is important since a recommended fungicide may fail to control a disease due to changes in climatic conditions or emergence of resistant strains of the fungus after repeated use. The agro-chemical company or agent is therefore required to provide CRIG with a minimum quantity of the product, at no cost, when it is requested.

10.3. Annual renewal of certificates of recommended fungicide

Monitoring of recommended and approved fungicides is continuously done through surveys, random sampling from farmers, agro-input shops and COCOBOD warehouses. Data on fungicides regarding efficacy, ease of application, user discomfort/side effect, correct packaging
(weight or volume), proper labeling and farmers/sprayers suggestions and comments are evaluated. Results from the survey are corroborated in laboratory tests on the samples and used to renew, modify or withdraw certificates of recommended fungicide from continuous use on cocoa in the country.

12 ACKNOWLEDGMENT

The authors wish to acknowledge Drs. R. Acheampong and G. Ameyaw Akumfi for their constructive criticisms, suggestions and comments on the preparation of this bulletin. The authors also wish to acknowledge the encouragement of the laboratory staff of the Mycology section of the Plant Pathology Division of CRIG to document the procedures followed at the section. We are also grateful to Mr. Kofi Nuamah Appiah for the layout design. This bulletin, CRIG/06/2013/037/004 is published with the kind permission of the Executive Director, CRIG.

11 FURTHER READING
