ASSESSING THE OPTIONS FOR SPRAY INTERVENTIONS TO CONTROL THE *MONILIOPHTHORA* DISEASE COMPLEX OF COCOA IN ECUADOR

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Abstract

We describe a series of field tests that examine the relative efficacy of control agents for the management of frosty pod rot (*Moniliophthora roreri*) and the witches' broom pathogens (*Moniliophthora perniciosa*). Research and development to date has focused on the optimisation of delivery systems for chemical fungicides and microbial control agents (MCAs) through improved MCA formulation, field testing and spore monitoring techniques.

Only copper hydroxide sprays significantly increased yield in the Rio Lindo fungicide trial during 2005: which was a dry year with relatively low FPR incidence. Taken together with other trials, copper fungicides remain the most robust recommendation for the protection of pods against the *Moniliophthora* diseases. In order to be cost-effective, the number of spray applications should be kept to a minimum, and we report that an economic benefit can be achieved with 5 sprays per season. *Trichoderma* spp. have a potential role in lowering levels of disease inoculum and reducing the number of chemical sprays. Results to date indicate they might best be deployed as part of a "mixed regime" that includes copper hydroxide for pod protection: and which appears to have little deleterious impact on *Trichoderma* in the field. The use of such interventions is discussed in the context of safety with pesticide use and other IPM measures, such as the need for good crop canopy management. This research programme serves to back-stop farmer participatory training co-ordinated by the ACDI-VOCA and Andean Countries Cocoa Export Support Opportunities (ACCESO) initiatives.

Introduction

Most cocoa (*Theobroma cacao* L.) farmers are small-holders, who usually minimise inputs for pest and disease management and, when cocoa prices are low, may not intervene at all. However, pod diseases caused by *Moniliophthora roreri* (Cif.) HC Evans (frosty pod rot: FPR) and witches' broom disease (WBD): *M. perniciosa* MC Aime & W Pillips-Mora, have the capacity to reduce yields dramatically in Latin America.

Although it has been established that the two *Moniliophthora* diseases are related, there is growing evidence that contrasting effects may occur with different control agents. Nevertheless, there are also similarities: previous testing on *M. roreri* in Costa Rica (Hidalgo *et al.*, 2003; Bateman *et al.*, 2005) included the oxathiin fungicide flutolanil, which was selected because of reported activity against WBD by Laker (1991) and appeared to be efficacious during 3 seasons. Copper fungicides provided the most effective FPR control: but had limited efficacy with a benefit / cost ratio of approx 1.7 after 8-10 sprays (at 2003 prices); there was little response from applications of two triazoles (during 1 season). The micro-fungal control agent (MCA) *Clonostachys byssicola* was ineffective in the field (Hidalgo *et al.*, 2003), but more promising results have been obtained recently with isolate of *Trichoderma ovalisporum* (Holmes *et al*, these proceedings). The most recent review of fungicide efficacy against the *Moniliophthora* diseases in Ecuador is given by Durango (2001), who showed that asoxystrobin (Bankit SC) gave at least as good control as the chemical standard (clorothalonil plus copper oxide). A crude formulation of *Trichoderma* was probably *T. koningiopsis* and produced significantly less infection than the controls.

The overall objective is to investigate levels of efficacy for alternative fungicides to copper, for the control of the mixed regime of *Moniliophthora* diseases found in Ecuador. In contrast to previous trials in Costa Rica, where typically 8-10 sprays / season were applied, in this trial series we are attempting to maximise cost effectiveness by reducing the number of sprays to approximately six per season, depending on disease levels at the beginning of the main harvest period (July).

Materials and Methods

Spraying started in the Rio Lindo plantation in February 2005. The trial area consists mostly of CCN51: with trees planted at approximately 1300 trees/ha. This is clonal cocoa showing some resistance to witches' broom disease (although cushion galls can be found frequently) but is susceptible to FPR and *Phytophthora* diseases. Cocoa in Rio Lindo is irrigated – causing high humidity in the cocoa throughout the year. Fig 1. shows the rainfall patterns and specific data for 2005.

The trial design focused on control agents, with a uniform means of application: Jacto PL-50-BV motorised mistblowers, fitted with pink restrictors (0.9 L/min) to give measured volume application rate of approx. 125 l/ha). The treatments are shown in Table 1. Together with the copper fungicide standard and control, we included manufacturers' recommended application rates of: two oxathiin fungicides (following the success of flutolanil in Costa Rica), a strobilurin, a second chemical standard: chlorothalonil and a mixed regime. The latter included a "disinfectant" spray at the start of the season, followed by experimental *Trichoderma* formulations and copper fungicides to protect pods at the end of the season.

Each plot consisted of 9 x 9 trees (Fig. 2), of which 49 are sprayed (S/A) with 5 x 5 = 25 trees assessed (A) surrounded by untreated trees (X). Occasional use of trees in boarder (S) rows enables compensation for missing trees.

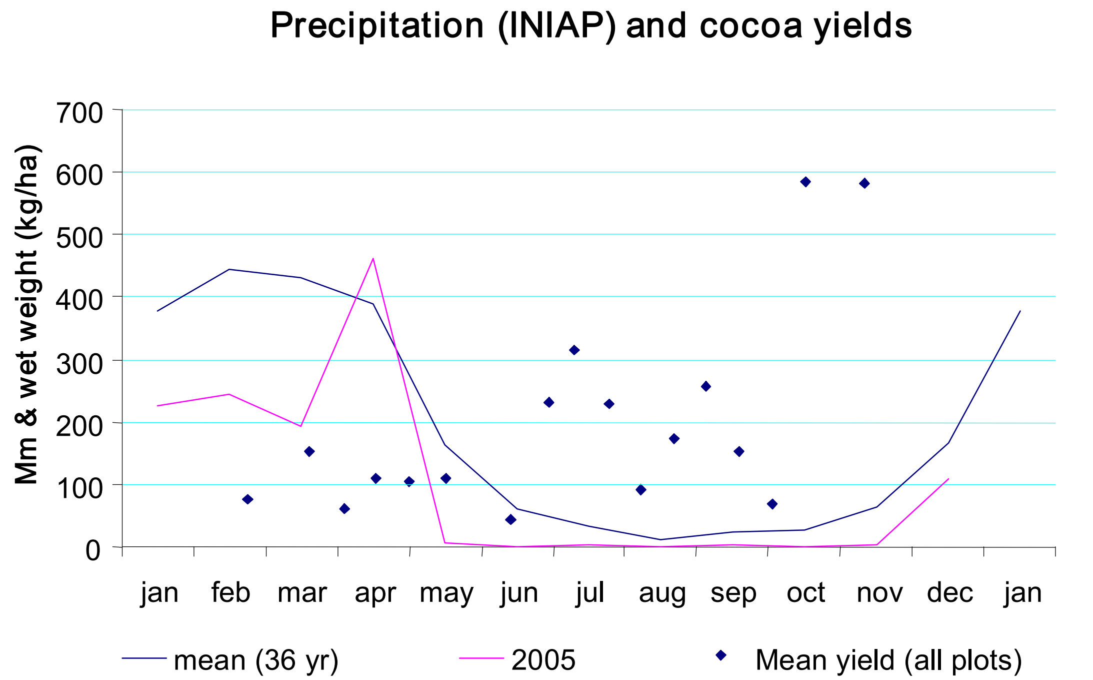

Fig. 1. Rainfall data from INIAP, Pichilingue (approximately 10 km from Rio Lindo) superimposed on mean yields from all plots in the 2005 trial (see below).

Table 1: Treatments for the fungicide trial at Rio Lindo, 2005

	Treatment	formulation		rate a.i.
1	Control	Water		
2	copper hydroxide	Kocide	Cu: 50% WP	1900 g.a.i./ha
3	flutolanil	Moncut	20% SC	125 g.a.i./ha
4	oxycarboxin	Plantvax	75% WP	300 g.a.i./ha
5	azoxystrobin	Bankit	25% SC	160 g.a.i./ha
6	clorothalonil	Bravo	72% SC	900 g.i.a/ha
7	mixed regime	1 application 'Bravo', 2 x *Trichoderma**, 2 x 'Kocide'		

* approximately equal rates of *T. stromaticum* and *T. koningiopsis* @ 2 x 10^{12} conidia/ha

X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
X	X	S	S	S	S	S	S	S	X	X	S	S	S	
X	X	S	A	A	A	A	A	S	X	X	S	A	A	
X	X	S	A	A	A	A	A	S	X	X	S	A		
X	X	S	A	A	A	A	A	S	X	X	S	A		
X	X	S	A	A	A	A	A	S	X	X	S	A	A	
X	X	S	A	A	A	A	A	S	X	X	S	A	A	
X	X	S	S	S	S	S	S	S	X	X	X	X	X	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	
X	X	S	S	S	S	S	S	S	X	X	X	X		
X	X	S	A	A	A	A	A	S	X	X	S	A		

Fig 2. Tree lay-out in plots

Results

After a relatively dry cropping season in 2005, WBD appeared to be more important than FPR with no significant differences in levels of the latter with treatments. Flutolanil appeared to reduce the incidence of wilted cherelles and WB pod lesions, but not significantly and actually resulted in the lowest yield. Only copper hydroxide provided significant increase in wet yield (P = 0.01; see Fig. 3) and there was an estimated 23% increase in dry yield, which might result in a $234/ha increase in crop value (Table 2). This represents a benefit/cost ratio of approximately 2.4 times. Cost calculations are based on my model for full operational costs – which are considerably greater than fungicide costs alone and include labour, sprayer amortisation, *etc*. On a 200 ha estate, five copper hydroxide sprays might represent a $47,000 return on investment at 2005 prices.

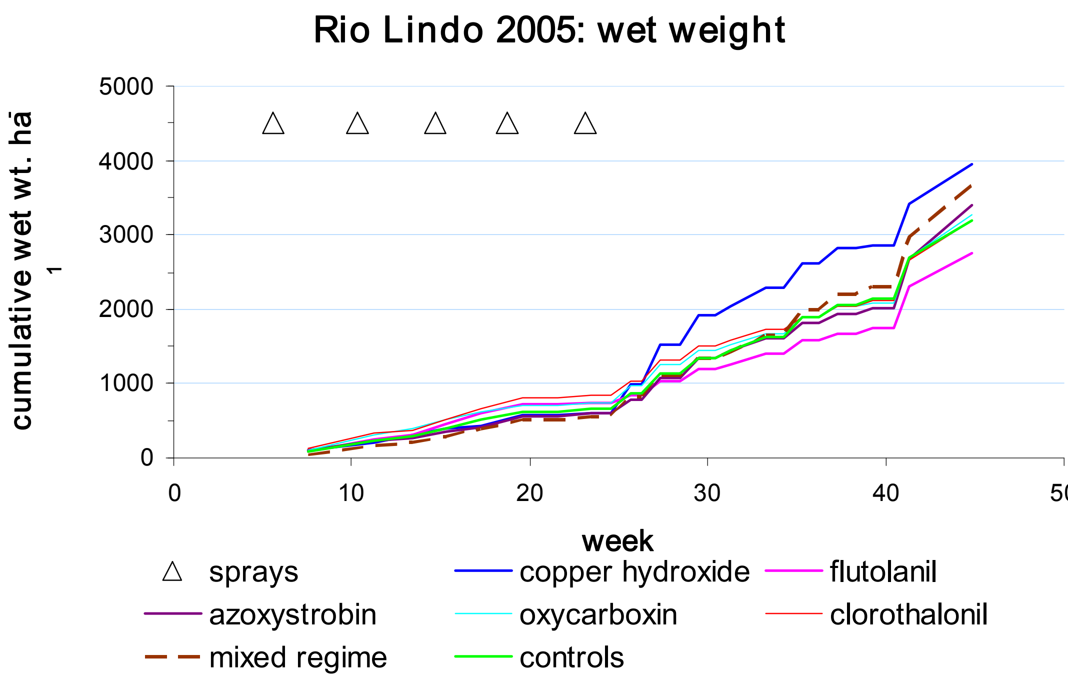

Fig. 3. Wet weight of cocoa produced by treatments in the Rio Lindo 2005 fungicide trial. Only production with copper hydroxide sprays is significantly different from controls (total production by November: l.s.d. = 553 kg/ha).

Table 2: Benefit-cost of using 5 sprays copper hydroxide (3 kg 'Kocide' per Ha per application) based on the Rio Lindo 2005 trial results (assumptions: 40% conversion & $1.33/kg)

	Estimated dry weight	difference	Increased value	Fungicide cost	Total spraying cost	profit / Ha.
copper hydroxide	1577	298.8	$398	$60.00	$164.15	$234.29
mixed regime	1461	182.7 (n.s.)	$244	n.a.		
Controls	1278					

Discussion

This trial is the first of a series, which has continued (with minor modifications) into the 2006 season: treatments continue to represent a range of fungicidal modes of action, that have performed well in previous trials or elsewhere. Copper hydroxide and clorothalonil are chemical standards. The latter belongs to WHO/EPA toxicity class II, and operators complain about skin irritation, and a priority is to is to identifyeffective but less toxic alternatives (class III or better). One of our intended goals is to help eliminate the use of toxic control agents by unprotected spray operators. The mixed regime (treatment 7) consists of an initial "sanitary" spray with clorothalonil followed by two inoculative *Trichoderma* sprays then applications of copper for pod protection. The oxathiin fungicide oxycarboxin has been withdrawn from the trial since it did not appear to show any efficacy in 2005 and has not been included on the annexes of the EU91-414 directive. In future years, it should be profitable to focus on optimising mixed regime options: including split-plot designs with enlarged *Trichoderma* treated areas and examining interactions with other control measures.

This research programme serves to back-stop farmer participatory training co-ordinated by ACDI-VOCA and the Andean Countries Cocoa Export Support Opportunities (ACCESO) initiative, which has included guidance on spray application (see Fig. 3). We would like to stress that high yields (say >1000 kg/ha) are needed in order to make spraying, or any other intervention, cost effective. Thus, growing a healthy crop, managing tree architecture, diseased pod removal and regular harvesting remain priorities. However taken together with other trials, we have shown that copper hydroxide may be appropriate and remain the most robust recommendation for pod protection using sprays against the *Moniliophthora* diseases

The economic benefit/cost ratio with copper hydroxide was achieved principally by minimising the number of sprays; in future, such ratios may be difficult to maintain with dramatic increases in copper prices. Akrofi *et al.* (2003) discussed the economics of fungicide applications (against *Phytophthora* spp. in W. Africa) and suggested that a ratio of >2 should be considered an economic return. Five sprays of copper fungicide at 1.5 kg.a.i./ha (3 kg product) keeps below the 8 kg copper/ha/year threshold that may be acceptable for organic cocoa production! However organic production accounts for only a small proportion of cocoa grown, so it is important to define what might constitute an objective for inundative biological controls such as *Trichoderma* sprays.

We suggest here that a reasonable objective might be to provide a level of control that is equally cost effective as copper hydroxide (if not better). The environmental benefits of biological control have been discussed extensively at INCOPED and COPAL. The social benefits (another pillar of sustainability) might include local manufacture, but mechanisms must be established to ensure quality control (see Bateman *et al.* these proceedings). Our progression from lab experiments to field trials with MCAs was accelerated for two reasons. Firstly there was urgency to implement techniques, with requests for alternatives to chemicals from farmer and extension groups. Secondly, concerns have often been expressed about following an excessively "chemical model" for microbial agents: are we are in danger of saying the "microbes don't make very good chemicals"? We believe that questions like these are best resolved by implementing rigorous field tests at the earliest possible stage.

Fumigando Cacao: 10 puntos esenciales

1. Mantenga la altura del árbol bajo control

Los árboles altos son difíciles para:

- monitorear
- fumigar
- cosechar

Pode los árboles regularmente: bajar la altura de los arboles (a 3 – 4 m) facilitara las aspersioness, pero usted dejara de cosechar durante un ciclo!

courtesy J.Cooper, NRI

2. Conozca su objetivo

¿Qué está tratando de controlar?

¿Qué producto usar y cómo lo aplicará?

Ejemplos:

Cerciórese de que no sea **demasiado tarde** para fumigar .

3. ¿Qué fumigará?

Elija y utilice el pesticida correcto:

Piense en seguridad primero.

….y en la eficacia…

Lea la etiqueta - ¿es el mejor pesticida para solucionar su problema?

Esta etiqueta significa cuidado

NO use productos peligrosos si no dispone de equipo de proteccion personal (EPP), como: máscara, gafas, guantes*, *etc*.

* **NOTA:** es más seguro no utilizar guantes que usar guantes con agujeros!

TOXIC

Esta etiqueta significa peligro

4. Protección Mínima Personal

- ✓ **Use un sombrero** para las gotas que caen
- ✓ Use ropa cómoda, que proteja su cuerpo, tanto como sea posible, los brazos y piernas.
- ✗ … pero nunca se ponga overoles u otra ropa contaminados
- ✓ Una cobertura facial es especialmente importante para pesticides peligrosos: puede hacerla a partir de una botella de gaseosa de 2L sujeta con una piola.
- ✓ Use los pantalones fuera de las botas
- ✓ Si usted utiliza una **bomba o rociador a motor,** los protectores de oído son esenciales.

Los niños no deben participar en las actividades de fumigación: ellos son extremadamente sensibles a los pesticidas

5. ¿Su rociador trabaja correctamente?

- ❑ Elija un rociador resistente….. y, ¿podrá encontrar repuestos para el mismo?
- ❑ **Antes** de cada operación de fumigación **revise** el equipo, utilizando agua limpia
- ➢ ¿Hay averías u obstrucciones? Revise la bomba, válvulas, filtros y boquillas.
- ➢ ¿Hay alguna fuga? Si los repuestos no están disponibles repare las uniones con cinta blanca o cinta de caucho, (puede ser hecha de los tubos internos de neumáticos viejos) Cambie las mangueras gastadas y con fugas.

6a. ¿Cómo tratar el objetivo?

¿Donde se debe aplicar el producto del rociador?

→ en mazorcas & troncos
→ brotes
→ árbol entero

Seleccione la boquilla correcta - si su rociador tiene una boquilla hueca de cono variable, ¿qué ajuste debe seleccionarse?

Las boquillas variables son difíciles de calibrar - es mejor seleccionar la boquilla correcta para el trabajo.

Más detalles están disponibles en … INIAP IPARC

Fig. 4. Spanish version (page 1) of the leaflet / poster *Spraying Cocoa* (for English and other language versions - see www.dropdata.net), showing the appropriate technology face visor developed at INIAP (centre-right).

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