THE SAFE USE OF PESTICIDES IN COCOA AND

HARMONIZED LEGISLATION FOR FOOD SAFETY

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Brazil’s perspective on legislations and other measures for pesticide safety in cocoa

João Louis Pereira* (Ph.D.)

CEPLAC/CEPEC, C.P. 7, 45 600-970, Itabuna, BA, Brazil
e-mail: pereira@cepec.gov.br

*Chairman, Scientific Research Committee, Cocoa Producers’ Alliance &
* Founder Chairman, International Group for Cocoa Pests and Diseases (INCOPED)
Diseases from the **Site of Origin** of Cocoa - **Witches’ Broom**

*(Monilophthora perniciosa)*

- Developing green brooms
- Infected dry brooms
- Infected pod, producing basidiocarp / inoculum
Diseases from the **Site of Origin** of Cocoa - **Witches’ Broom**

Cont...

Necrotic lesion on pod surface

The extent of damage to beans in pods
Diseases from the **Site of Origin** of Cocoa - **Frosty Pod Rot**

*(Monilophthora rorera)*

**Healthy pods**

**Diseased pods displaying a range of symptoms**
A Disease of Pandemic Importance—Phytophthora Pod Rot

Natural field infection.

Various stages of infection including to mummified diseased pods.

Artificially inoculated pods with the three species (from left to right) *Phytophthora citrophthora*, *P. palmivora* and *P. capsici*, showing their different rates of development.
Early Use of **Protective Fungicides** for Cocoa Disease Control

- As early as 1907 in the Cameroons, disease control commenced with the use of copper-based chemicals sprays of Bordeaux mixture, prepared as in Europe and applied for the control of Phytophthora pod rot. Fernando Po was the next in 1930’s and Nigeria in 1936.

- In Brazil, fungicides for cocoa were first experimented on in 1956, also for Phytophthora pod rot. In the 1960’s routine applications increased progressively treating 10,000 ha of cocoa in 1970, to 170,000 ha in 1980.

- The wide use of protective copper-based fungicide in many countries worldwide, (since 1885 in Europe), demonstrated that this active ingredient allowed for:
  - An acceptable level in disease;
  - Build-up of resistance by pathogenic fungi was not recorded;
  - Residues in cocoa beans were not recorded;
  - To-date no cases of toxication of spray operators have been reported;
  - Neither detrimental effects the environment or;
  - Phytotoxicity (including the cocoa tree).
Protective Fungicides for Cocoa Disease Control

- Therefore, copper was and is the main active ingredient opted for use in Brazil, however, in a wettable powder, pre-prepared formulation.

- The three compounds of copper fungicides used (cuprous oxide, copper oxychloride and cupric hydroxide) have been manufactured in Brazil, mainly as a 50% metallic copper concentration. Cuprous oxide invariably gave slight superior disease control, compared to the others.

- In 1983, in an attempt at reducing cost of protective fungicides, a tin compound, 20% fentin acetate (LD50 acute oral rats 125mg/kg) was screened. Mixtures were prepared combining a small part of tin, (a ratio of 1:9, tin to copper). Results produced gave a significant cost reduction, and higher efficacy compared to the standard dose of either of these products. However, precaution in the use of this product continued.

- Following early detection of tin residues in cocoa beans, the recommendation for fentin acetate was withdrawn.
Systemic Fungicides for Cocoa Disease Control

- The advent of systemic fungicides came with a promise of translaminar movement from the upper sprayed surfaces to the lower, unsprayed surfaces. Others, fungicides are taken up and redistributed through the xylem vessels to the upper parts of the plant.

- However, in a tree crop, as cocoa, many of these systemic fungicides have limited translocation ability, added to which, a risk of a build-up in pathogen resistance, when repeatedly exposed to the product.

- Further, systemic fungicide are often pathogen specific, limiting their use, when compared to some the more economic wide-spectrum products.

- Copper for example, is routinely used for the control of two diseases - witches’ broom and black pod, as they share virtually the same treatment timing, thus allowing for a considerable cost reduction, in protecting young pods to maturity/production.
None-the-less, in a disease management strategy, it is important to have in reserve well worked on candidate systemic fungicides with curative properties, to be applied when protective / preventive fungicides are unable to secure a severe disease outbreak.

Therefore, over the last 25 years, in Brazil, as part of routine research activities at the Research Centre, candidate systemic fungicides have been screened for different pathogens. Added to this, in-dept academic studies (At post-graduate level) on modes of action of the fungicide to the pathogen, operating pathways and the potential in economic use.

The selection process on seven systemic candidate fungicides for Phytophthora pod rot showed a range in efficacy, tested at 10,000ppm to 10ppm. Five of these were superior i.e. metalaxyl, phosetyl-Al, eridiazole and propamocarp, in which even at 10ppm there was some inhibition of fungal growth.

Recently, a relatively new product tebuconazole is being put through field-scale testing for control of witches’ broom

In Brazil, probably in function of expected curative properties, the cost of these organic systemic compounds are inaccessible for routine use in farms, operations, if need to be used they would have to be subsidised.
**Introduction: Scenario of Insect Pest in Brazil**

- The State of Bahia, Brazil’s main cocoa growing region, over three decades ago was plagued with insect pests of cocoa.

- At that time, for lack of a selective insecticide benzene hexachloride (BHC) in a powder formulation was repeatedly applied, indiscriminately toxic to fauna including beneficial insects. The situation changed only following a government ban on the use of BHC. Other selective insecticides of lower toxicity, however more expensive were beginning to be introduced.

- Insect pest is no longer a serious problem in Brazil. Possibly, excluding BHC allowed for an increased population of insect predators and parasites that dealt with the damaging pest. However, today, insecticides do not have to be applied routinely, but only occasionally to deal with mild infestations.

- Three insect pests may require attention and periodically these are: thrips (*Selenothrips rubrocinctus*), sucking bugs (*Monalonion bondari*) and beetles (*Taimbezinhiphia theobromae*). Organophosphorus insecticida malathion and Deltamethrin are recommended.
Insect Pest of occasional importance in Brazil
Thrips - *Selenothrips rubrocinclus*

- **Nymphs**
- **Adults**
- Rust type symptoms on leaves
- Severe loss of leaves on tips of branches
Insect Pest of occasional importance in Brazil

Sucking bugs  Monalonion bondari

Nymphs  Injury to stems

Adult  Injury on pods

The insect pest  Damage caused
Insect Pest of occasional importance in Brazil

Beetles *Taimbezinhia theobromae*
The main form of weed control has been manual slashing. However, over the last eight years, the minimum salary was adjusted annually, this increase cost to the farmer allowed for only one manual slashing a year.

To maintain control of different weeds species, at the same time to limit cost, at least one application of glyphosate, a broad-spectrum systemic herbicide is sprayed over the whole area.
Brazil, has the world’s largest pesticide equipment manufacturing plant, in which, I had the opportunity to set up a sector to research on bio-physical aspects related to pesticides.

The motorised knapsack mist blower, considered ideal for spraying cocoa, even with all its modification continues to be ill-suited for operational and economic reasons to spray small holdings, that constitute about 80% of all farms.

Brazil, in 1983 assembled a prototype of a multiple hose and lance system, coupled to a semi-stationary hydraulic pump - max. output 40l/min at 35kg cm² and powered by a diesel engine (4.5hp), with a work output similar to eight motorised mist blowers, which gives no discomfort in carried weight, noise and vibration.

The total operating cost of this unit was 58 to 67% less than the motorised mist blowers for similar output, plus numerous benefits. Since then, this system has been considerably improved, scaled-down with lighter engine coupled pumps.

With 140,000ha of selected clones grafted on existing cocoa trees, which is then drastically prunned, and the graft establishes, now, a smaller canopy and tree height. This allows for pesticide transfer to be less wasteful or polluting.
The six motorised mist blowers available in Brazil were subjected to detailed comparative evaluation for pesticide application in cocoa.
Technology in pesticide transfer

Semi-stationary hose and lance hydraulic spraying system
Research in Screening for Pesticides and Residues in Beans

- Candidate pesticides are selected based on recently published research data and information released by pesticide companies on new improved products. These are then investigated specifically for use in cocoa for: efficacy, novel mode of action, relatively lower toxicity/residues and a positive cost/benefit, at the effective dose and number of applications expected in field use.

- Initially to determine the effective dose, laboratory bio-assays examine a range of concentrations for lethal effect of the pesticide on the pathogen, insect pest or weed. Then in a series of statically designed field experiments of variables type and dose, number of applications and interval of application are compared to the best standard to-date. These studies continue for at least 3 years.

- In the absence of analytical methods or infrastructure to determine chemical residues of newer products in our centre, coded samples of treatment variables from field plots are sent to independent laboratories or the supplier of the product for determining residues.
Research in **Screening for Pesticides and Residues in Beans**

- Clearly if a risk exist, a sure way to counteract this risk is by installing well equipped toxicology laboratories to conduct residue analysis on cocoa beans, in producing countries. **A statistically acceptable sample of beans is needed from consignments prior to export or before release for domestic consumption.** Due to its very scale, this call for joint program between the producers and buyers.

- Knowing which of the pesticides are registered as safe and if these are the only ones in use, does not constitute a problem. In Brazil research centres associated to a crop, or a commercial company are required to register a new pesticide intended for public use for the first time in an agricultural food crop. Requirements for this register are determined by the Ministries Agriculture, Health and Environment, covering all possible aspects of food safety and toxicity levels to humans, fauna and flora, in its original form, or as breakdown products. An approved pesticide can then be recommended to farmers.

- However, if for reasons of cost or any other the farmer seeks alternatives of cheaper low grade products, then we really have a problem!
‘Good Agricultural Practices’ (GAP) or Cocoa Growers’ Manual, pamphlets, updates, as prepared by the Research and Extension Services in cocoa producing countries have always been a set of vital document aimed at more efficient and productive cultivation.

These generated recommendations have to be transferred to the lesser technologically prepared farmers in small holdings.

It is the very farmer that then has to decide, as to the choice or combination of agricultural practices. However, this decision remains governed by the constraints of the farm’s modest budget...and this is where the cocoa productive chain starts – with a dependence solely on the returns received by small-holder farmer.
Good Agricultural Practices (GAP) in the Context of Crop Protection

- Inappropriate decisions (i.e. short of what is recommended) in the application of GAP and specifically in the case of rational use of pesticides is not due to a lack of understanding of the rudiments of cost/benefit, which has never been the case with farmers, but the determining factor is the farm budget, with its narrow lee-way for manoeuvre.

- Providing the world a continuous supply of cocoa should not be the only objective of GAP. It is equally important that the application of GAP be an economically viable and affordable series practices, to ensure cocoa farmers apply GAP and benefit in having their cocoa trees in a state of good health and husbandry.
Good Agricultural Practices (GAP) in the Context of Crop Protection

*The Present State of Pesticides Usage in Bahia, Brazil*

<table>
<thead>
<tr>
<th></th>
<th>ESTIMATED TOTAL OF COCOA CULTIVATED AREA</th>
<th>TREATED WITH HERBICIDES</th>
<th>TREATED WITH FUNGICIDES</th>
<th>TREATED WITH INSECTICIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HECTARES</td>
<td>459,208</td>
<td>21,567</td>
<td>16,744</td>
<td>12,424</td>
</tr>
<tr>
<td>PERCENTAGE OF THE TOTAL</td>
<td>--</td>
<td>4.69%</td>
<td>3.65%</td>
<td>2.71%</td>
</tr>
</tbody>
</table>

Based on the above total cultivated area, the mean productivity was 301kg/ha

Source: Ceplac/Cenex, 2010
Increasing awareness in Safe Crop Protection as a means to Achieve Cocoa in Quality and Quantity.

- In a recent International Cocoa Research Conference a count of the number of scientific papers presented in each of the nine scientific sessions, gave an insight as to the demand of research in resolving crop protection limitations.

- The results demonstrated that studies in the Session Crop Protection ranked highest at 31% of all papers, followed by Agronomy, Physiology, Soils and Nutrition at 23% and Genetics and Breeding at 21%.

- Again, on-going studies, within Crop Protection, ranked Diseases at 81% of global cocoa research, followed by Insect Pest at 13% and all other ‘Pests’ at 6%.

- In Brazil, a large team of crop protection specialists, aim at a concept that fungicides and insecticides, should in principle, be used as an emergency measure to keep in check an outbreak of disease or pest infestation and then phased out to other more safe and durable means of management.

- We believe we have made advances, and hope to show that we are indeed on the right track.
Recommendations generated from research facilities, as an example in Brazil, were considered as Agricultural Practices or GAP.

These combined in sets give rise to Technological Packages. Each of the technological packages (example: T. 0 to T. 6) were designed to include a determined number of inputs, that would result in a level of activities compatible to an expected productivity.

In T. 0, the number/combination of agricultural practice would have to be minimal, associated to what small holder farmers’ budget will allow for, within an expectation to produce a modest average 300kg/ha.

At the other end of the scale, a farmer expecting to produce an average 1,200kg/ha from a large farm would apply another technological packet (T. 6) in which, a selection of more available agricultural practices, would be compatible to the scale of a large investment.
<table>
<thead>
<tr>
<th>Agricultural practices</th>
<th>Related to cocoa in kg/ha</th>
<th>Nº of applications</th>
<th>Total cost per ha/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Weed control by slashing</td>
<td>33.00</td>
<td>1</td>
<td>33.00</td>
</tr>
<tr>
<td>2 Removal of non-contributing vegetative growth/base suckers</td>
<td>14.10</td>
<td>2</td>
<td>28.20</td>
</tr>
<tr>
<td>3 Pruning and canopy formation</td>
<td>56.70</td>
<td>1</td>
<td>56.70</td>
</tr>
<tr>
<td>4 Inspection and phyto-sanitary removal of infected material</td>
<td>6.60</td>
<td>2</td>
<td>13.20</td>
</tr>
<tr>
<td>5 Control of insect pest by dusting</td>
<td>9.90</td>
<td>2</td>
<td>19.80</td>
</tr>
<tr>
<td>6 Control of diseases (6g i.a. Cu++)</td>
<td>83.85</td>
<td>3</td>
<td>251.55</td>
</tr>
<tr>
<td>7 Liming</td>
<td>50.40</td>
<td>1</td>
<td>50.40</td>
</tr>
<tr>
<td>8 Mineral fertilisers (NPK)</td>
<td>268.95</td>
<td>1</td>
<td>268.95</td>
</tr>
<tr>
<td>9 Weed control with herbicides</td>
<td>25.80</td>
<td>1</td>
<td>25.80</td>
</tr>
<tr>
<td>10 Nitrogen fertilisers</td>
<td>61.95</td>
<td>1</td>
<td>61.95</td>
</tr>
<tr>
<td>11 Thinning of shade trees</td>
<td>22.20</td>
<td>1</td>
<td>22.20</td>
</tr>
</tbody>
</table>

**TOTAL** 831.75 2,299.32
Agricultural practices leading to technological packages, expected returns, cost of technology, margin of profit, cost/benefit ratio

<table>
<thead>
<tr>
<th>Code</th>
<th>Sets of Agricultural Practices</th>
<th>Expected returns</th>
<th>Cost of technology</th>
<th>Margin of profit</th>
<th>Cost/Benefit Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 0</td>
<td>1+2+3+4</td>
<td>300</td>
<td>228.90</td>
<td>71.10</td>
<td>1.31</td>
</tr>
<tr>
<td>T 1</td>
<td>1+2+3+4+5</td>
<td>450</td>
<td>288.90</td>
<td>161.10</td>
<td>1.56</td>
</tr>
<tr>
<td>T 2</td>
<td>1+2+3+4+10</td>
<td>540</td>
<td>487.20</td>
<td>52.80</td>
<td>1.11</td>
</tr>
<tr>
<td>T 3</td>
<td>1+2+3+4+5+10</td>
<td>630</td>
<td>529.65</td>
<td>100.35</td>
<td>1.19</td>
</tr>
<tr>
<td>T 4</td>
<td>1+2+3+4+5+7+8</td>
<td>720</td>
<td>673.65</td>
<td>46.35</td>
<td>1.07</td>
</tr>
<tr>
<td>T 5</td>
<td>1+2+3+4+6+7+8</td>
<td>900</td>
<td>897.15</td>
<td>2.85</td>
<td>1.00</td>
</tr>
<tr>
<td>T 06</td>
<td>1+2+3+4+5+6+7+8</td>
<td>1,200</td>
<td>992.55</td>
<td>207.45</td>
<td>1.21</td>
</tr>
</tbody>
</table>

*The monetary values in the study refer to, as of on 31st May 2008.
AN ATTEMPT TOWARDS AN IMPROVED DISEASE MANAGEMENT STRATEGY

1. PHYTOSAN
   Reduction in inoculum

2. CHEMICAL
   Protective action on developing pods

3. BIOLOGICAL
   Reduced development of the pathogen and less viable spores

4. GENETIC
   Introduction of plants with inherent lower levels of disease in the field

Pre-1989: limited components of disease management for witches’ broom
AN IMPROVED DISEASE MANAGEMENT STRATEGY

1. PHYTOSAN.
   - Reducing inoculum

2. CHEMICAL
   - Protection or curative action on pods to infection

3. BIOLOGICAL
   - Reduction in development of the pathogen and viable spores

4. GENETIC
   - Level of disease is intrinsically lower in resistant plants.

Post-research: additional contribution to components in witches’ broom disease management by ‘pyramidising’ effect of components operating individually and concomitantly within a strategy.
Conclusions

- In this presentation, if to understand the whole picture I intentionally did not separate crop protection from pesticide safety. More so, in dealing with a crop of the humid tropics.

- Pesticides are essential, for the simple reason that without crop protection, no matter how good the application of GAP in crop production, is there is no guarantee that the resultant potential crop will carry to harvest.

- In my working life more than seven pesticides that after years of research input and recommended being considered as safe products, had to be withdrawn – this process is continuous; we know too little which chemical will be proven harmful, years later!

- This is not rewarding to crop scientist, detrimental to the field operators of the products and not healthy to the consumers.
Conclusions

- As seen in the presentation, in Brazil, we are moving away from the use of pesticides, and at this moment the levels of pesticide applied in below five percent of the total planted area, and well below this level in the actual quantity used. Seldom if ever a full recommended schedule is applied, directed due to its cost.

- We have worked towards strengthening other components in pesticide management strategies and for the first time supply of genetic material with inherent resistance and biological agents that target on pests and proved to be self-perpetuating as an epiphyte.

- Therefore, `Brazil’s perspective on legislations and other measures for pesticide safety in cocoa` we are moving away from the use of pesticide, and without realising, we are almost onto organic cultivation of cocoa.
Thank you!  Terima kasih!