A NEW SYSTEM TO PROTECT STORED COCOA BEANS FROM INSECTS WITHOUT THE USE OF METHYL BROMIDE

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Cocoa beans are imported into the United States to be processed into chocolate, and hence are an important item of trade. According to the U. S. Department of Commerce, in 1996/97, 353,323 metric tons of cocoa were received through 16 U. S. ports. These beans were worth $466,343,499, or nearly half a billion dollars. These beans are often infested with stored-products insects when they arrive in the United States, and are consequently fumigated with methyl bromide before being placed in stateside warehouses. Over the past five years the American Cocoa Research Institute, which represents the major chocolate companies, has been investigating the feasibility of using alternative approaches to reduce or eliminate the infestations of warehouse moths and beetles before the beans arrive, so as to have some replacement when methyl bromide is phased out in 2001.

Initial tests have indicated that a combination of two alternative or "natural" insecticides can protect cocoa from warehouse moths, and perhaps from some beetles. These alternative insecticides are *Bacillus thuringiensis* and neem. The intent is to apply the insecticides when the beans are shipped from the producing country, and perhaps earlier. The protection they afford should last a least six months, and perhaps as long as a year.

Now for a little more information about the two insecticides, and how they are to be applied. *Bacillus thuringiensis*, or *B. t.* for short, is a bacterium that secretes a protein crystal when it forms a spore. This crystal is toxic when eaten by insects along with the bacterial spores in their food. We have been using the formulation DiPel 2X WP, manufactured by Abbott Labs. This formulation is a wettable powder based on the strain *B. t. kurstaki*. In our lab tests, we have applied the DiPel directly to the beans in a novel way, namely, as a powder or dust, instead of as a liquid mix. To ensure dispersal, we mixed the powder with ordinary bleached flour. For any field tests we will probably use cocoa powder as the carrier instead. About $0.33 of DiPel per 64 kg bag of cocoa will kill over 99% caterpillars of the almond moth, which is a major pest of cocoa worldwide.

The second alternative insecticide, neem, in contrast to *B. t.*, is an oil, which has been extracted from the Indian neem tree, *Azadirachta indica*. The particular form we are using is Trilogy 90 EC. This is manufactured by Thermo-Trilogy, Inc. We've also applied the Trilogy in a novel fashion, that is, to the burlap sacks, and not to the cocoa itself. In sacks that are exposed to the air, as for example in an ordinary warehouse, the neem acts as a repellent. It was for this use that we originally added it to our system. It is also inexpensive. About $0.09 worth of Trilogy per bag is sufficient to repel almond moths.
We believe that if instituted our system of using neem and *B. t.* with each other should compare favorably in cost and effectiveness to present fumigation practices. We would

only have to treat the beans once in the producing country, whereas in the present system they may fumigated three or four times before being made into chocolate. The system should become even more attractive in the future, as the cost of methyl bromide will raise considerably if it is retained as a specialty chemical. The system is also very easy to apply, and therefore ideally suited to the small-scale conditions under which most cocoa is currently grown.

During our research we also found that neem worked extremely well as an insecticide, if the vapors had a chance to build up without dispersing. In one test using almond moth, continuous exposure to vapor from sacks treated with $0.27 Trilogy resulted in over 99% kill, for a period of over 6 months. We also tested the $0.09 dose against cigarette beetles. Here, we found that an exposure of the eggs and young larvae for about two weeks resulted in significantly fewer F1 beetles, about six weeks later. We believe it is likely that the higher, $0.27 dose would have resulted in a complete kill.

The insecticidal properties of neem vapor are entirely dependent on vapor build-up within an enclosed space. Recently, we hit on the idea of using air-tight PVC cocoons to limit dispersion of the vapor from treated sacks. These cocoons are designed to be used with a controlled atmosphere of either CO_2 or N_2. Their air-tightness makes them the perfect vehicle to hold sacks of cocoa that have had their burlap treated with neem. If the test referred to above is any indication, we think cocoons filled to capacity with treated sacks could be insect-free for up to a year, and perhaps longer.

We are currently working towards a large field test for both of the systems described above, and have asked both the EPA and USDA for funding. As I write this, it is likely that in 1999 we will test a neem/PVC cocoon system in Panama using about 600 bags of beans, and the original neem/*B. t.* system in Indonesia, using about 200 tons.

In summary, our program using neem and *B. t.* offers:

- a quick easy way of treating any amount of cocoa beans in the producing countries
- with treatments that will afford continuing protection from warehouse moths for at least six months and perhaps for much longer
- that will cost about the same as the total amount for insecticides applied today

The modification we plan to make using just neem and PVC cocoons should offer:

- treatments that will afford continuing protection from all insects for up to a year
- at a fraction of the cost for current fumigations