MALATHION SYMPOSIUM INTRODUCTION

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Abstract

Today we want to present information on malathion applied as technical in an ultra-low volume (ULV) spray against the boll weevil in area-wide eradication programs across the cotton belt in the United States. The eradication program is effective. This is because the use rate of technical malathion is an extremely effective contact insecticide against the boll weevil. It is the only registered insecticide applied in technical form to cotton. It was registered for use on cotton in the early 1950s and it has been used on cotton in various formulations ever since. Technical malathion is registered for use in a "Boll Weevil Attract and Kill Tube" with cottonseed oil-shellac formulation.

Malathion is one of the safest insecticides to mammals and it is registered for use on cotton. Technical (96+%) malathion has an oral LD50 of 5,500 mg/kg for rats. The other 3+% are inerts. When placed on rabbit skin dermal LD50 was 2,000 mg/kg. Inhalation of malathion is >5.2 mg/liter of air space. Malathion will volatilize with vapor pressure of 4x10-6 mm mercury at 30°C. Malathion is an alkyl phosphorodithioate. Technical is a clear amber liquid and is heavier than water.

Producers are and have been at war against the boll weevil since the turn of the century and will be fighting this war into the next century. After the war has been won in the United States it should be continued in Mexico and the rest of the Americas.

Cost is such an important criteria that it has to be taken into consideration when conducting an eradication program. Cost of any action can make or break any area wide program so care must be taken. Cost of technical malathion is $4.00/acre including its application for the program. This makes it affordable when used in an area-wide eradication program. It is difficult to justify and economically prohibitive for producers to use a more expensive insecticide in a program.

Technical malathion has desirable physical properties. It flows easily through the nozzles of an airplane at its use rates. It can be applied with ground equipment if it is diluted correctly. Coverage for adequate toxicity by technical malathion to the boll weevil on cotton has to be achieved and the 12 oz/acre volume meets this requirement. When technical malathion is applied at 12 oz/acre it will kill >90% of the boll weevils for 4 d. Distributing this 12 oz over an acre requires global positioning system (GPS), the correct application equipment and minimal wind speeds. Each application must provide adequate coverage with enough technical malathion to insure that the weevil will contact the malathion when walking on the plant or impinging a droplet on the weevil present on the plant at the time of application. At lower volumes control will not be adequate because coverage will not be adequate.

Technical malathion can be readily formulated into an emulsifiable concentrate, wettable powder or encapsulated and diluted in water. These formulations are not used in the program because water is an enemy of efficacy against the boll weevil. It is also more expensive to use because the water has to be carried by the airplane. Formulations with water will be more evenly spread over the leaf surface than the technical. Malathion molecule will be subjected to degradation in cells of the leaf surface and internal leaf and bract tissue. These degradation products will not be toxic to the boll weevil. Technical malathion will form droplets as each molecule would be in close proximity. In formulations with water malathion molecules would be separated by molecules of solvents, adjuvants and water.

Two other organophosphorus insecticides could be used against the boll weevil, but the mammalian toxicity of these insecticides is greater than malathion. Other insecticides have been proposed, but they have factors such as shorter residual toxicity, cost of the insecticide and parallel cost of application in water which render them less desirable for use.

In addition to the choice of technical malathion against the boll weevil it is the insecticide of choice against mosquitoes which transmit diseases from animal host to animal host. Technical malathion is applied as ULV with all these applications. Whole cities in the United States have been treated by airplane for control of the various species of mosquitoes. It is the insecticide of choice when diluted in liquid baits against Mexican and Mediterranean fruit flies in tropical countries. Cities and whole areas of tropical countries have been treated to prevent their presence in fruit exported to the United States.

Efficacy of malathion against other pests of cotton is considered. Malathion as a ULV spray is toxic to the bug species *Lygus*. With ULV malathion diluted in cottonseed oil 100% of nymphs and adults were killed in 24 h in a laboratory test (Mulrooney 1999, unpublished data). Results indicate that technical malathion is highly toxic to *Lygus* and thought should be given to including its control as a plus in the eradication program.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1060-1062 (2000)
National Cotton Council, Memphis TN

Malathion is not very effective against lepidopteran pests of cotton. In fields of cotton sampled all season continued damage to squares showed toxicity was minimal to larvae of the beet armyworm in the Lower Rio Grande Valley of Texas in 1995. Malathion is not highly toxic to susceptible strains of third-instar larvae of the bollworm/tobacco budworm except on the day of application (Table 1). Mortalities on 1-2, 4-5 and 6-7 d were <50%.

The question of resistance by the boll weevil to malathion is of importance because of its use in the eradication program. As far as I know there is no resistance, nor has there been, to this insecticide anyplace in the United States. Bioassays in Texas and Louisiana have confirmed this. Eradication successes in southeastern states and the far west have discounted resistance in the southeast and in the southwest to date. But this author has to suggest that its use on all cotton in any given geographic area over a four year period could be a setup for resistance by the boll weevil. This is selection pressure so the possibility has to be suggested. Because the insecticide is applied over the entire geographic area we could encourage resistance in secondary pests or beneficial insects. Resistance by an effective beneficial species against any pest would be welcome. In the area-wide treatment program the toxicant is placed on all cotton plants at one time.

Resistance by the boll weevil to malathion applied topically to the adult was shown in southern Tamaulipas in 1995, but not in 1996 nor 1998 (Table 2). Bioassay with field collected weevils of leaves sprayed with malathion from 1994 to 1998 showed poor toxicity. Perhaps this is because malathion was applied as emulsifiable concentrate in water.

If an LD50 is >10 I think the insect will be difficult to control in the field where the insects were collected. Malathion is not used in Mexico on cotton so how did this happen? Did another insecticide widely used in the area induce this resistance to malathion? What caused this resistance to occur in 1995 and then be lost in 1996 from a field less than 1 km away? These are questions for us to ponder.

It is known that the phosphatase and carboxylesterase enzymes will detoxify malathion in insects other than the boll weevil. It is also known that synergists such as butifos will prevent the activity of theses enzymes. This is what happened (Table 3). Butifos reduced the LD50 of malathion in 1998 17-fold. If the LD50 in 1995 was 17-fold less the population would be susceptible. The LD50 would be <1 and I suggest that this LD50 indicates susceptibility.

When to initiate sprays of technical malathion in a eradication program is a problem when conducting an area wide program. If all cotton could be planted within 2 or 3 days in a given area timing of the first application would be easier. In subtropical areas there is no evidence to show that sprays made to cotton prior to the first damaged squares is economically feasible. If applications of technical malathion were made during the last half of the season before the populations initiate dispersal kill of the boll weevils would be more efficient.

Boll weevil populations and damage could be eliminated by planting no cotton. They can be reduced by applying insecticides to cotton. Insecticides are, by far, the primary and often the only means producers have to prevent damage to fruit each season. The adult is the target stage of all boll weevil insecticides. Adults of this insect are probably the most difficult stage to kill, but no insecticide applied as a foliar spray can contact the larvae in squares and bolls.

Different numbers of applications of malathion can be used in different areas of a defined geographic area of any eradication program. Number of applications to dryland cotton can be reduced compared to number of applications to irrigated cotton. Dryland cotton will grow slower than irrigated cotton. Thus, residues of malathion will last longer than on irrigated cotton. This is shown in the plains area of Texas where both dryland and irrigated cotton are grown. Presumably, fewer weevils inhabit each field of dryland cotton and there would be better coverage of the smaller plants in dryland cotton than in irrigated cotton. The biggest problem with this suggestion is the lack of information on the timing and number of applications of malathion to dryland or irrigated cotton of any area. The only question—will malathion be present on enough plants in the geographical area to contact all the dispersing boll weevils? Growers who treat their individual fields simply cannot replace the effectiveness of an area-wide treatment of all fields where weevils could be present. Boll weevils survive in fields treated three to five days earlier and disperse to fields treated days later where they oviposit on squares.

Use of technical malathion as a ULV spray in area-wide eradication programs should be continued until no boll weevils are found in the United States. Monitoring of populations will have to be continued year after year in most areas, especially those in southern latitudes. A few fields in these areas will have to be treated each year because damaging populations will be found. Fields with minimal populations may comprise only 0.001% of the fields in any area; this is 10 fields for every 10,000 fields planted. All of us must accept the fact that the boll weevil is a survivor; this means that one can be present in a field each year.

Residual toxicity of malathion to the boll weevil, ease of application, cost and reduced toxicity to mammals compared to the other effective insecticides make it the insecticide of choice for the program. No alternate insecticide has all the advantages of malathion.

Following this introduction we will learn the history of how technical malathion came to be the choice for this program. Then we will learn about the advent of the ULV application which was spawned by malathion. We will focus on the principles and logistics involved in the use of technical malathion over a defined area which will result in none to one boll weevil in any field of cotton after four years.

We will learn about the toxicity of malathion to the myriad of insects and arachnids more commonly called beneficials. Beneficials include both predators and parasites of any pest species. There is no naturally occurring species of beneficial that will control the boll weevil for the entire season, but I feel that it is more important to kill the pest than it is to not kill beneficials. Regardless, it is our desire to protect the myriad of species that comprise the beneficials so they will be available to eliminate or reduce the homopteran, hemipteran and lepidopteran pest species.

The latest information on transference of technical malathion from the leaf to the boll weevil and its toxicity at various rates by aerial application is presented. Transference of technical malathion diluted with cottonseed oil from the leaf to the boll weevil at lower rates indicate that a total volume of 12 oz/a, containing 6 oz/a malathion, could be as effective as the 12 oz/a of malathion alone. Residues of malathion on the leaf and the boll weevil were used to show coverage and subsequent toxicity.

Information will be presented on formulations of malathion which can be applied with ground sprayers. Restrictions on aerial application of ULV malathion near homes and bodies of water require the evaluation of ground sprayers which can reduce the drift of the fine particles from the ULV applications applied by airplane and still be effective against the boll weevil.

Information about experiences of past and present eradication programs are needed. The past program in the Southeast underwent an evolution of methods. The choice of insecticides was changed from North Carolina to Alabama.

The program within Texas has its own evolution. Success has been shown in Southern Rolling Plains and Coastal Bend/Winter Garden areas. In the late 1960s a successful program was conducted in the High Plains of Texas. Different insecticides can be used by programs in the United States and Mexico. The timing and applications of the area-wide treatment in both countries may be the same or different depending on the location or growing conditions. The key will be an effective and economical area wide treatment program.

I hope that each of you take away some information that will be helpful to you in your endeavors. Let's continue with the presentations.

Table 1. Toxicity of technical malathion after 48 h to bollworm/tobacco budworm applied as ULV spray at 2.8 kg (A.I.)/ha. Progreso, TX. 1970. [1]

Days	Mortality (%)
0	90
1-2	48
4-5	32
6-7	22

[1]Taken from Wolfenbarger and McGarr (1971). USDA Production Research Report 126. 14 pp.

Table 2. Toxicity of malathion after 48 h to boll weevil. Estacion Cuauhtemoc, Tamps. Mexico.[1]

Year	LD50 (µg/adult)	Dead after spray (%)
1991	4.38	
1992	1.75	
1993	3.09	9
1994	1.45	27
1995	10.69	2
1996	0.94	19
1998	0.96	

[1]Taken from Teran-Vargas, A. P. and J. Vargas-Camplis 1994. Proc. Cotton Insect Research and Control Conference pp 1024-1025 from 1991 to 1993. Taken from Teran-Vargas1994 to 1998 (unpublished).

Table 3. Toxicity of malathion with two synergists after 48 h against boll weevil. Ebano, San Luis Potosi, Mexico.[1]

Synergist and malathion	Fold <LD50 than malathion	LD50 of 1995 strain
Butifos	17	0.63
Piperonyl butoxide	3	3.56

[1]Taken from A. P. Teran-Vargas (unpublished).