IV. CHEMICAL CONTROL OF MOLE CRICKETS (R. L. Kepner)

Beginnings

The introduction, in about 1900, and subsequent spread of pest mole crickets quickly aroused the attention of farmers along much of coastal Georgia. By 1909 mole cricket damage had become so severe that immediate remedial action was warranted. In 1910 the state of Georgia initiated a three year study to determine an economically effective means for controlling this serious threat. Various control techniques such as metal barriers, light traps, and repellants were attempted but had limited success. It was concluded that poison baits concocted of various mashes of bran, corn, or cottonseed meal, mixed with paris green or calcium arsenate, offered the best control.

Poison baits, broadcast over the soil surface or buried in trenches around individual plants, provided the only economically effective control of mole crickets for several decades. As mole crickets continued their spread through the southeastern United States, recommended bait formulations were changed in response to claims of improved control by incorporating low grade flour or egg mash. In addition to poison baits, soil treatments with lead arsenate and soil fumigation with carbon bisulfide or calcium cyanide were recommended for control by 1930.

Mole crickets had spread well into Florida by the 1930s and populations soon reached epidemic levels. In 1940, central Florida's vegetable growing areas experienced the worst infestation of mole crickets ever reported in the United States. Hundreds of growers made appeals for assistance, and in response the USDA Bureau of Entomology and Plant Quarantine set up an emergency mole cricket control program. Growers were supplied with 120 pounds of 7½% calcium arsenate, bran bait per acre to be applied in three applications of 40 pounds each throughout the growing season. Studies were initiated to develop a more economical bait but were soon suspended because of World War II.

Until the mid-1940s, poison baits were the most efficient means of suppressing mole cricket populations, but with the advent of synthetic insecticides in 1944, a new era of control began. Persistent, highly toxic contact poisons such as DDT and chlordane were found to be very effective against mole crickets. Baits were no longer considered the best method of control, and efforts to improve bait formula-

tions diminished. Though not as effective as contact poisons, baits were still used, since they were economical and growers were accustomed to them. The only change was that chlordane became the toxicant.

Chlorinated hydrocarbon insecticides, especially chlordane in the form of baits, sprays, and dusts, became the standard control agents for mole crickets because they offered economical, long-term control. In the early 1970s, problems with residues on food and forage crops caused most of these insecticides to be removed from use in many areas where mole crickets were a problem. In addition to restrictions on its use, chlordane had become less toxic to mole crickets by the mid-1970s, probably because the crickets had developed resistance. With the loss of efficient, long-term control agents, IFAS Extension personnel began a continuing series of screening tests in search of new insecticides effective against mole crickets. Some were found, and these are the basis of present chemical control. However, these insecticides proved less persistent and more costly, and, as a result, mole crickets became increasingly difficult and expensive to control.

Present Day Control

Chemical control of mole crickets is presently accomplished by soil treatments with baits, sprays, and granules.

Baits

In many instances, such as in pastures, chemical control is limited to the use of baits, since irrigation and/or soil incorporation is not feasible. Though baits are the most economical of all control measures, costs are still high (Table 5), and control is not always adequate.

Controlling mole crickets with poison baits can be very effective if applications are properly timed. The use of baits takes advantage of mole cricket feeding behavior. Under favorable conditions, mole crickets will come to the surface and forage for food. While burrowing through the soil, they periodically leave their tunnels and search the soil surface. It is this behavior that makes the use of baits so attractive. If a poison bait is present when a large percentage of mole crickets are feeding on the surface, control will be maximized. It is best to treat with baits during the summer months after eggs have hatched and weather conditions are most favorable (see Fig. 10). If baits are applied early in the summer when the nymphs are small, control can be obtained before significant damage has occurred.

Table 5. Insecticide formulations labeled in Florida for control of mole crickets on various crops.

Treatment	Formulation		Rate (lb A.I./acre)	Registered use	Approximate cost of materials per acre
BAITS:	Malathion	2%	1–2	turf, pasture	$24–48
	Trichlorfon	5%	1–1.5	pasture, field crops	$15–22
	Carbaryl	20%	1–2	turf, pasture	$25–50
	Propoxur	2%	2–4	turf	$130–260
	Chlorpyrifos	0.5%	0.75	turf	$55–82
SPRAYS:	Diazinon	2 EC	5	turf	$32
	Diazinon	4 EC	1	vegetables	$6
	Propoxur	70WP	2–4	turf	$60–120
GRANULES:	Ethoprop	10G	10	turf	$88
	Isofenphos	5G	2	turf	$64
	Isofenphos	1.5G	2	turf	$135
	Diazinon	14G	7	vegetables, field crops	$90

IMPORTANT NOTE: These insecticides are currently (1983) labeled for use in Florida, but registrations are subject to change at any time. *Consult your county extension agent for up-to-date control recommendations.*

Treatments during the spring months, when mostly adults are present, are not recommended, because adults do not accept baits as readily and the chances of reinfestation from subsequent flights and unhatched eggs are high.

Baits should be applied in the late afternoon or early evening, preferably soon after a rain. Mole crickets are most active on the surface at such times, when the soil is moist and temperatures are warm. If the bait is applied when the soil is dry or temperatures are cool, few crickets will be active, and little of the bait will be consumed. Sunlight and high daytime temperatures will then quickly degrade the bait and control efforts will be wasted. Also, rain soon after a bait application will leach out the insecticide and render the bait ineffective.

The proper timing of a bait application is a crucial step toward improving chances of control, but it does not insure success. Control ultimately depends on the proportion of mole crickets feeding and the amount of bait consumed. In an attempt to increase the effectiveness of chemical control and to make baits more economical, intensive investigations into bait formulation were undertaken.

These investigations have dealt with each of the four basic components of baits.

1) ***Attractants*** To improve the chances of mole crickets finding a bait, it should be made attractive from a distance. Such a bait could draw the cricket to the poison instead of relying on the cricket accidentally stumbling upon it as it randomly forages for food. Not only would attractive baits make control more efficient, but less bait would be required.

More than 45 materials were tested as possible food attractants for both tawny and southern mole crickets. Tawny mole crickets were not attracted to any of the materials tested, but southern mole crickets showed attraction to rancid hamburger and fish meal. These materials are not suitable bait additives, since they are highly unstable and costly, and are only attractive to the pest mole cricket of least economic importance.

2) ***Feeding stimulants*** Mole crickets, in their random search for food, will sample food before ingesting it. If the material is found palatable, its chances of being consumed are very high. Therefore adding a feeding stimulant to a bait should greatly enhance the probability that it will be accepted and consumed.

Over the years amyl acetate and molasses have been advocated as additives to enhance bait consumption. However, recent IFAS tests have shown that amyl acetate does not encourage feeding by either mole cricket species, and at high concentrations is a deterrent. There-

fore, it should not be used. Molasses proved moderately attractive to tawny mole crickets but not to southern mole crickets. Addition of molasses for pasture and turf is justified since tawny mole crickets do most of the damage in these areas. Several products are excellent feeding stimulants for both types of mole crickets. These are COAX (commercial feeding stimulant–$2.00/lb), brewers concentrate (brewery byproduct, $0.02/lb), malt extract ($0.46/lb), and crude cottonseed or soybean oil in combination with sucrose ($0.25/lb). Brewers concentrate appears to be a good additive for mole cricket baits, since it is slightly cheaper than molasses ($0.03/lb) and is significantly more attractive.

3) ***Carriers*** Carriers constitute the bulk of the bait and can account for greater than 50% of the material costs. Mole cricket baits have been formulated on a variety of materials, varying considerably in cost, including vermiculite ($0.45/lb), cottonseed meal ($0.16/lb), wheat bran ($0.15/lb), laying mash ($0.14/lb), cracked corn ($0.12/lb), corncob grits ($0.10/lb), and peanut hulls ($0.04/lb). Wheat bran, cracked corn, and laying mash are highly acceptable to mole crickets. Addition of feeding stimulants appears to enhance their acceptance only moderately. This is probably because these materials have some nutritional value and are therefore naturally palatable. Inert compounds such as peanut hulls, vermiculite, and corncob grits are not very palatable alone but become highly acceptable when feeding stimulants are added. Baits formulated with either corncob grits or sawdust, incorporated with malt extract, have proved as effective as laying mash-molasses bait in field plot tests. These results suggest that material costs can be reduced by at least 50% if baits are formulated on a cheap, readily available carrier such as peanut hulls.

4) ***Toxicants*** Mole crickets are susceptable to most insecticides. Of those most likely to be used in baits, chlorpyrifos (Dursban) and trichlorfon (Dylox, Proxol) are the most toxic and are effective as 0.5% and 1% baits applied at 2 pounds A.I./acre. These insecticides are expensive at $8 to $17/lb A.I. Malathion and carbaryl (Sevin) are not as toxic and therefore require more concentrated baits for good control but are significantly less expensive at $3 and $5/lb A.I., respectively. Baits formulated as 20% carbaryl or 2% malathion have both shown excellent control when applied at 2 lb A.I./acre. Therefore, using more concentrated baits formulated from less toxic insecticides could reduce toxicant costs as much as 50%.

5) ***Other components*** An ideal bait should remain both highly acceptable and toxic for an extended period of time under field conditions. The addition of waterproofing agents, antioxidants, or UV light

sunscreens to bait formulations may prolong the field life and therefore enhance control. No compounds of these types have been tested.

Sprays and granules

Soil treatments with sprays and granules are generally more effective than baits in controlling mole crickets since they do not rely on feeding, and timing is not as critical. But they generally require more insecticide per acre, are more expensive, and require some sort of irrigation or soil incorporation. Irrigation serves two purposes: 1) it carries the insecticide into the root zone; and 2) it encourages mole crickets to be active in the upper layer of soil where they can come into contact with the poison. Control with any of these treatments is best during the summer months for reasons previously explained. Ethoprop (Mocap) and isofenphos (Oftanol) are the best chemical treatments for mole crickets in turf. Isofenphos offers up to several months of control with a single application and is most efficient when applied early in the summer. Propoxur (Bayon) and diazinon (Sarolex) sprays are not as effective in turf as other registered formulations.

Evaluation of chemical control

In the past, the effectiveness of chemical controls has been evaluated by counting dead or moribund crickets on the surface. This can be misleading, since many crickets die below the surface. A chemical causing high mortality below ground could be rated ineffective. Additionally, the initial population is unknown, and movement into and out of the treated area is not accounted for. A technique developed to evaluate true chemical efficacy involves placing a known number of mole crickets in soil-filled cages or containers buried at soil level prior to treatment. Control can be accurately determined by counting the mortality both above and below the surface. This technique, though labor-intensive, is the most reliable means of comparing toxicity of chemical treatments.

Flushing live crickets from the soil with mild soap and pyrethrin solutions can also be used to evaluate chemical control. Because of the inefficiency of flushing, only a relative measure of control can be obtained. Other techniques involve measuring the extent of tunneling/damage or the number of plants destroyed. Like the flush, these techniques give only a relative measure of control but are useful for evaluating the long-term effects of chemical treatments.

Future Prospects

Unless resistant grass varieties or introduced biological control agents become established and permanently reduce the economic impact of mole crickets, chemical insecticides will remain indispensable for controlling mole cricket populations. At present, chemicals provide the only known means for quickly suppressing large numbers of crickets with predictable results.

Sprays and granules are the most effective insecticidal treatments for mole crickets, but their use will remain expensive and will be limited to non-forage crops. However, the recent registration of isofenphos, a long-term residual insecticide, will help reduce the cost of control in turf by lessening the need for additional treatments later in the season.

Because of recent concerns over indiscriminate and excessive use of pesticides, chemical control with poison baits has received renewed emphasis and is most promising for several reasons. Not only are baits relatively cost effective, but they offer an efficient and ecologically selective use of broad spectrum insecticides. Though they are the safest and most economical method of control, poison baits are, nonetheless, too expensive for practical application in pastures. Cattlemen and hay producers are left with no acceptable means of controlling mole crickets. There are some approaches promising more affordable chemical control.

1) As described in an earlier section, costs can be dramatically reduced by using less expensive materials in formulation, namely carriers and toxicants. A bait formulated from peanut hulls, brewers concentrate, and 2% malathion, and applied at recommended rates (1–2 lb A.I./acre), could cost as little as $5.00/acre.

2) The use of applicator-formulated baits offers a significant savings in material costs. A user-formulated 2% malathion bait (Table 6)

Table 6. Formulation and approximate cost of materials for a applicator-formulated 2% malathion bait.

Material	Amount*	Approximate cost**
Laying mash	100 lbs	$13.50
Crude molasses	2 qts	$ 0.50
Water	1–5 qts	—
Malathion	2 lbs	$ 6.00
TOTAL		$20.00

*Formula developed by P. G. Koehler and D. E. Short.
**Based on 1983 prices of quantities locally available to growers.

will save the grower more than 50% in the cost of materials when compared to a similar preformulated bait (Table 5) applied at the same rate.

3) Recent research suggests that the amount of material necessary for effective control can be substantially reduced. Chlorpyrifos 0.5% bait was 85% effective when applied at less than one-third the recommended rate (0.2 lb A.I./acre) to an extremely high population density (100 crickets/sq m). Laboratory tests have shown that malathion baits are effective at rates as low as 0.5 lb A.I./acre. Additionally the use of an applicator formulated 2% malathion bait (Table 6) has given excellent control in pastures when applied at 0.4 lb A.I./acre, less than half the recommended rate.

Though chemical control can be made more economical, it can only offer temporary relief. More permanent solutions are necessary to eliminate the severe impact of mole crickets. With pesticides becoming increasingly expensive and their environmental side effects of greater concern, selective and intelligent use of insecticides will be essential to mole cricket management in the future.

Addendum

Tests completed in 1984 proved that a single application of grower-formulated 4% malathion bait could give season-long control of mole crickets for as little as $3.50/acre in material costs.

The most effective bait tested was similar to the one described in Table 6, but was formulated with twice as much malathion (4%) and, instead of molasses, incorporated 5% crude cottonseed oil and 10% sucrose. Lab trials established that cottonseed oil and sucrose induced more feeding than molasses, and small-scale field trials demonstrated that 4% malathion was more efficacious than 2% (when applied at the same A.I./acre rate). Persistence studies found that the 4% bait retains half its toxicity for as long as 30 days under field conditions. In full-scale field trials in heavily infested bahiagrass pastures, one application of grower-formulated bait at 0.5 lb A.I./acre gave greater than 95% control for at least two months.