CONTROL OF ANT DAMAGE TO POLYETHYLENE TUBES USED IN DRIP IRRIGATION SYSTEMS IN HAWAIIAN SUGARCANE FIELDS

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ABSTRACT

Ant damage to polyethylene tubes used in drip irrigation systems is a major problem on some of the Hawaiian sugarcane plantations. Damage can be controlled by reducing ant populations, by injecting insecticide into the drip irrigation system, by using ant-resistant tubes, and by utilizing agronomic practices. Mirex bait was currently used to control ant populations. Injecting heptachlor into the drip tubes at dosage of 75 g/1000 m of tube was effective in protecting the tubes from ant damage for at least 12 weeks. Tubes made of polypropylene or polybutylene material were less damaged by ants than tubes made of low-density polyethylene material. Thick-walled tubes (greater than 0.25 mm) often have fewer holes chewed through by ants on tube walls. Slit orifices were attacked less frequently by ants than the round orifices. Incorporating toxic chemicals into tube material could eliminate ant damage for more than 3 months. A short, frequent watering schedule was preferred to a schedule with long periods of watering and shutdowns.

INTRODUCTION

The Hawaiian sugar industry had converted approximately 19,000 ha of sugarcane land from furrow irrigation to drip irrigation by the end of 1978. One of the major problems we have encountered in drip irrigation is that ants chew through the tube walls and enlarge the orifices along the length of the tube. This changes the hydraulic characteristics of the system, causing a reduction of water pressure resulting to an uneven water distribution. If the problem is not corrected, it could result in heavy yield losses in some parts of the field due to poor plant growth caused by severe water shortage. With an increasing number of fields converted to drip irrigation in Hawaii, the problem of ant damage to drip tubes becomes a serious threat to the well-being of the industry.

Three ant species in Hawaiian sugarcane fields cause the damage then are the fire ant, Solenopsis geminata (F.), the big-headed ant, Pheidole megacephala F.,
and the Argentine ant, *Iridomyrmex humilis* (Mayr.). All of these ants make their nests in the soil or partly in the soil. The fire ant is the most destructive but its distribution is limited to hot, dry and low lands. It nests often in sunny, open areas, among short grasses or in partial shade. Within a sugarcane field, fire ants can be found anywhere when the leaf canopy is open. Ten months after planting however, more fire ant nests are located near the field margins, usually less than 15 m from the border areas (Chang *et al.*). 

The big-headed ant is widely distributed in shady and moist areas, often nesting near the soil surface under the trash or in old sugarcane tools. They remain in sugarcane fields throughout the crop season and can caused extensive tube damage when their population is high.

The Argentine ant is dominant in areas generally above 150 m in elevation. We have not observed severe tube damage caused by this ant species.

Ant damage to drip tubes can be reduced by the following approaches:

1. Reducing ant populations
2. Establishing a toxic barrier around the orifices
3. Using ant-resistant drip tubes
4. Utilizing agronomic practices

This report covers our work on these approaches. It discusses the problems we encountered in conducting the study and gives some of the results we obtained.

**MATERIALS, METHODS AND RESULTS**

**Reducing Ant Populations In Sugarcane Fields**

An obvious answer to the problem of ant damage to drip tubes is to reduce the ant population in the field. Insecticides for ant control in crop lands have been applied in two ways — by baits and broadcast applications to the soil.

Mirex Granulated Bait 300 (0.3% mirex, 15% soybean oil) on a corn or maize cob grit carrier was used for reducing ant populations in drip-irrigated sugarcane fields. It gave effective and economical control, but the registration for use of Mirex was cancelled by the United States Environmental Protection Agency (EPA) on December 1, 1977, with a provision that stocks on hand after that date could still be used until exhausted. A new bait by American Cynamid, AC 217300, is under study and may be used in the future if the chemical is proven effective and economical.

Of the residual soil insecticides tested to replace Mirex bait, the most effective ones were the chlorinated hydrocarbons such as chlordane, aldrin, dieldrin and heptachlor. However, these insecticides were all being phased out of used by the EPA. None of the other short-residue pesticides already registered for used on
sugarcane such as diazinon and endosulfan (Thiodan) were effective.

We have always been cautious in using broadcast application of insecticides in Hawaiian sugarcane fields because of potential harmful effects on natural enemies of many sugarcane insect pests. Negm and Hensley showed that after suppression of the ant population by soil surface treatment with heptachlor, damage by *Dia- traea saccharalis* (F.) was significantly increased. However, we do not preclude experiments to explore the use of certain newer pesticides such as the synthetic pyrethroids.

We prefer to use bait to reduce ant populations because it is specific, easy to apply, and a small amount of active insecticide is needed on a per area basis. For instance, in using Mirex bait, only 8 g/ha of active material was applied at a cost of about U.S. $10.00/ha. Because of this small amount, there was a minimum effect on other non-target insects and beneficial insects. This fitted in well, with our overall insect pest management program.

*Establishing A Toxic Barrier Around The Orifices*

Most of ant damage to the thick-walled (over 0.36 mm) drip tubes occurs at the orifices, which can be protected by injecting a contact insecticide into tubes that are buried in the soil. The insecticide is injected into the water while the irrigation system is in operation and saturates the soil around the orifices to establish a toxic barrier to keep ants away.

We have evaluated the effectiveness of a number of insecticides in preventing ant damage to drip tubes. The results showed that tubes treated with heptachlor at a dosage of 75 g/1000 m of tube had no orifice enlargement after 12 weeks of exposure, while control tubes had 23% and 13% of the orifices enlarged by the fire ant and the big-headed ant, respectively. Registrations of heptachlor on food crop except for uses under specified exemption were cancelled in February 1978 by the U. S. EPA. We have been granted registration for local use of heptachlor by the Hawaii State Department of Agriculture. We have not conducted tests with heptachlor over an entire crop cycle of 24 months. Nevertheless, we believe that by re-treating the fields at proper intervals, heptachlor will provide adequate protection of the drip tubes until the sugarcane crop is harvested.

The use of heptachlor as an alternative to Mirex baits to control ant damage to drip tubes is a temporary answer. We do not look at heptachlor as a permanent solution because of its potential adverse effects of the environment and other non-harmful organisms (especially beneficial insects). Other insecticides showing promise are the synthetic pyrethroids such as fenvalerate and permethrin at a dosage of 30 g/1000 m tube. These insecticides are less persistent in the environment and should have fewer problems being registered for crop use by the EPA. However, these are not as effective as heptachlor and are more expensive.
Another method of establishing a toxic barrier is by soaking the drip tubes in solutions of insecticide or insect repellent. Results showed that tubes soaked for 3 hours in 0.4% diesel oil solution of fenvalerate had 1% of the orifices enlarged by the fire ants after 3 months exposure in the field. Twenty percent of the orifices were enlarge on the untreated tubes. Unfortunately, it is not possible to re-treat the tubes with this method also, 3 months of protection is not adequate since the average harvest age for Hawaiian sugarcane is 24 months. We have discontinued studying this method of establishing a toxic barrier.

**Ant-resistant Tubes**

A. Factors affecting resistance of tubes to ant attack

Many types of drip irrigation tubes from different manufacturers are currently available on the market. Each type is of different material, construction, wall thickness, orifice configuration, and orifice size. We compared some of these attributes for their roles in ant resistance.

1. **Type of material.** We found that polypropylene and polybutylene materials are most resistant to ant damage than the low-density polyethylene material. The orifice diameters on polypropylene material were enlarged to only \( \frac{1}{4} \) and \( \frac{1}{2} \) of the sizes of orifices on polyethylene material by the fire ant and the big-headed ant, respectively, after 7 days of exposure. Work with other insects also showed that polypropylene is more resistant to penetration, than polyethylene. At present, however, virtually all tubes installed on Hawaiian plantations are polyethylene.

2. **Wall thickness.** The wall thickness of drip tubes currently available commercially ranges from 0.13 to 0.76 mm. We found that ant damage decreases with increasing wall thickness. The fire ant enlarged the orifice diameter of 0.15-mm-thick polybutylene material to 616\% of its original size in 7 days, while the orifice diameter on 0.73-mm-thick material was only enlarge 32\% during the same period. Also, ants often chew directly through the tube wall if the thickness is less than 0.25 mm. Increasing the thickness of plastic materials has been reported to reduce termite damage in a similar manner (Gay and Wetherly).

3. **Orifice configuration.** Tube manufacturers use either a laser beam or a mechanical punch to make tube orifices. Result of tests in our laboratory showed that orifices made by a mechanical punch or by a cold needle had only \( \frac{1}{2} \) to \( \frac{1}{3} \) the amount of ant damage to the orifices made by a heat process (Chang and Ota).

The orifice shape also makes a difference. We found that slit orifices, as on the T-Tape tubes (T-System Corporation, San Diego, California), had less ant damage than round orifices. Field results showed that the slit orifices of T-Tape had no enlargement vs. 29\% of the round orifices enlarge after 139 days in a sugarcane field infested with big-headed ants.
This was possibly due to the fact that, while slit orifices remain closed when the tube was not used for irrigation, round orifices remained open. The ants walked by slit orifices without detecting them; whereas they investigated and probed into round orifices. Also, closed orifices made it difficult for ants to insert their mandibles to initiate chewing. They have no difficulty with the open, round orifices.

B. Incorporation or impregnation of plastic with chemicals

Polyethylene-blend drip tube material can be made more ant resistant by incorporating chemicals. Chang and Ota\(^2\) also reported that certain organic compounds were highly effective in reducing ant damage. More recently we have incorporated the insecticides heptachlor, bendiocarb, fenvalerate permethrin, and propoxur into the low-density polyethylene materials. The preliminary field results showed that material incorporated with 0.5% by (weight) fenvalerate had no orifice enlargement vs 457% increase for orifices on the untreated material after 104 days in naturally occurring fire ant nests in the field. However, the results from different trials were in consistent due to difficulties in mixing chemicals into the hot (300\(^{\circ}\)C) polyethylene material in our laboratory.

Kirkhill Rubber Company (Brea, California) has produced three tube materials with toxic chemicals, for us to test for ant resistance. One of these materials was undamaged by ants after being buried in naturally occurring ant nests in the field for 104 days. In contrast, the orifice diameter of untreated polyethylene-blend tube material was increased 352% and 453%, respectively, by the fire ant and the big-headed ant. We are hopeful that tubes made up to the latter material will be available for further field tests.

Gay and Wetherly\(^4\) and Beal et al\(^1\) incorporated insecticides and inert fillers into PVC plastics hoping to increase termite resistance. Gay and Wetherly\(^4\) showed that the only materials without any termite attack were the ones incorporated with aldrin and dieldrin. PVC materials incorporated with 5% hard silicon, zircon flour or diatomaceous earth could reduce termite attack to only 66-80%.

Agronomic Practices to Reduce Ant Damage

Chang and Ota\(^2\) showed that tubes buried or in constant darkness had significantly more ant damage than tubes placed on the soil surface and subjected to continuous light. Ants would be unlikely to attack hot tubes laid on the soil surface under the sun, whereas a cool buried tube could be attacked day and night. However, the difference in ant damage may not be significant after the closing of the leafy canopy.

The sugar plantations in Hawaii do not irrigate the fields continuously because of water shortages. Instead, drip irrigation systems are run at intervals. Ants cannot attack the orifices when the irrigation system is operating. Thus, a
watering schedule of short, frequent irrigation rounds will result in less ant damage to tubes than one of long watering periods (over 2 days) and long shut-downs (Chang and Ota7).

DISCUSSION

At present, we do not know why ants chew polyethylene tubes. Chang and Ota2 indicated that ants are attracted to water and to low concentrations of \( \text{CO}_2 \) which could be released at the orifices from microbial activity on organic matters brought by irrigation water into the tube. Hangartner5 showed that \( \text{CO}_2 \) also elicited a digging response in the fire ants. It was possible that ant enlarge the orifices to gain access to the tube interior in search for food or water, or a nesting site, especially since we have noticed ant broods in the tubes. However, we still cannot explain why the ants chew the polyethylene tube wall. Ants usually initiate the attack on the wall areas with surface blemishes. Beal et al1 reported that smoothing the surfaces of the material was about as effective as doubling thickness in reducing termite perforations. However, Gay and Wetherly4 showed that the physical nature of the surface of a plastic is of no importance in determining the liability of the plastic to termite attack.

In our opinion, the best solution to reduce or eliminate ant damage to drip tubes is the development of an ant-resistant tube which relies basically on physically and hydraulic characteristics. For instance, the most commonly used tube in Hawaii has a wall thickness about 0.56 mm and double-wall construction, so that they hydraulic characteristics of the tube are more tolerant to ant-damage orifices. Using this tube, it has been unnecessary to treat for ants in many fields that do not have the fire ant. However, the tube cannot withstand damage by the fire ant or high populations of the big-headed ant and insecticide treatments are required.

Incorporation of chemicals into the tube material will continue to be explored. Recent developments indicate that new candidates of potential chemicals used in conjunction with modern plastic technology may make it feasible to develop tubes that are resistant to ants. However, we must still consider the safety problem in manufacture and handling, the cost, and the process of registration and approval by the U. S. EPA.

REFERENCES


EL CONTROL DEL DAÑO DE HORMIGAS A TUBOS DE POLIETILENO EN EL SISTEMA DE RIEGO POR GOTEÓ EN CANALES DEL HAWAII

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RESUMEN

El daño de las hormigas a los tubos de polietileno usados en el riego por goteo, es un problema serio en ciertas plantaciones de caña del Hawaii.

El daño puede controlarse al reducirse la poblacion de hormigas, ya sea mediante la inyección de insecticidas en el sistema de riego, usando tubería resistente, o utilizando ciertas practicas agronomicas. Mirex* es el producto que normalmente se usa en Hawaii para el control de las hormigas. Al inyectar heptacloro en las tuberías, a dosis de 75 g/100 m. de tubería, se protegen los tubos del daño de las hormigas por lo menos durante 12 semanas. La tubería de polipropileno o polibutileno es mas resistente al ataque de las hormigas que las de polietileno de baja densidad. Los tubos de paredes gruesas (mas de 0.25mm) presentan menos daños. Los orificios de salida longitudinales, en forma de rajaduras, son menos atacados que los redondos. Al incorporarse material toxico en la materia prima componente de la tubería, se elimina el daño por mas de 3 meses. Un programa de riegos cortos y frecuentes es mas aconsejable que periodos largos de riego e inactividad.

*Insecticida de tipo hidrocarburo clorinado.