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# EFFECTIVENESS OF REDUCED RATES OF INSECTICIDES FOR THE CONTROL OF *MELANOTUS COMMUNIS* (COLEOPTERA: ELATERIDAE) IN SUGARCANE

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Abstract

Wireworms (larval Elateridae) are perennial pests of newly planted sugarcane causing stand loss directly by damaging growing points and indirectly by introducing disease. Two organophosphate insecticides, phorate and ethoprop, are currently labeled for controlling wireworms in sugar cane. In the first experiment, 4 rates of phorate (100, 87.5, 75, and 62.5% of the current maximum field rate) were used in 2 different types of soil: Dania Muck and Immokalee Fine Sand. In the second experiment, 4 rates of phorate and ethoprop (100, 75, 50, and 25% of current maximum field rates) were used in a Lauderhill Muck soil. A no-treatment and a wireworm-free treatment were used as controls in both experiments. The effect of the insecticide was evaluated in simulated field experiments conducted in 18.9-L (5-gallon) buckets filled with soil and artificially infested with 10 wireworms (*Melanotus communis* (Gyllenhall), Coleoptera: Elateridae) per bucket. After 60 d, the contents of the buckets were emptied to evaluate damage to the plant and count the surviving wireworms. Insecticides resulted in fewer live wireworms and reduced damage to sugarcane shoots, roots, and seed pieces compared to the no-treatment control. In the first experiment, phorate proved to be very effective at controlling wireworms even at the 62.5% rate. Phorate was more effective in the Immokalee Fine Sand than in the Dania Muck. In the second experiment, phorate was found to be more effective at reducing stand loss and wireworm numbers than ethoprop.

Key Words: Elateridae, wireworms, phorate, ethoprop, histosol, spodosol

Resumen

Gusanos de alambre son continuos plagas insectiles en nuevamente sembrado caña de azúcar que reducen el número de plantas directamente por dañar el punto de crecimiento y indirectamente por introducir agentes patógenos. Dos insecticidas organofosforados, phorate y ethoprop, son registrados para controlar gusanos de alambre en caña de azúcar. En el primer experimento, se usan cuatro tazas de phorate (100, 87.5, 75, y 62.5%) de la taza máxima actual en dos suelos de tipo diferente: Dania Muck y Immokalee Fine Sand. En el segundo experimento, se usan cuatro tazas de phorate y ethoprop (100, 75, 50, y 25%) de la taza máxima actual en un suelo: Lauderhill Muck. Se usan una prueba sin insecticida y una prueba sin gusanos alambres como pruebas de control en cada experimento. Se evaluó el efecto de la insecticida en experimentos de campo simulados en baldes de 18.9 litros (5 galones), llenados con suelo, e infestados artificialmente con 10 gusanos de alambre (*Melanotus communis* (Gyllenhall), Coleoptera: Elateridae). A partir de 60 días, se vaciaron los contenidos de los baldes pare evaluar el daño a la planta y para contar los gusanos de alambre sobrevivientes. El uso de insecticidas reduce el número de gusanos de alambre sobrevivientes y reduce el daño al tallo, a la raíz, y la semilla en comparación a la prueba de control. En el primer experimento, phorate fue efectivo hasta la taza de 62.5%. Phorate fue más efectivo en el Immokalee Fine Sand que en el Dania Muck. En el segundo experimento, phorate fue más efectivo en reducir pérdida de plantas y números de gusanos de alambre que ethoprop.

Translation by the authors.

Wireworms (*Melanotus communis* (Gyllenhall), Coleoptera: Elateridae) have been a constant threat to sugarcane since the beginning of its production in the 1920s and 1930s in the Everglades Agricultural Area (EAA) (Gifford 1964). Prior to the advent of chemical insecticides some growers had to replant several times to get acceptable stands (Wilson 1940). Prior to the 1960s, most of the EAA was devoted to cattle production and a large percentage of the land that gradually would go into sugarcane production was devoted to pasture (Kidder 1979). Elevated populations of wireworms often are found in pasture or otherwise grassy fields (Fox 1961; Parker & Seeney 1997).

The wireworm is a hardy insect with a long life cycle of 1 to10 years depending on the climate of the area (Capinera 2001). Fields of sugarcane have been reported to have upwards of 100,000 larvae per hectare in histosols (Wilson 1946). Removing the food source by clean fallowing will starve out most of the worms and may prevent more oviposition in that field (Wilson 1946); however, it will not provide complete control (Cherry & Stansly 2007). Fallow flooding has proven to be very effective, but even flooding requires that the water be above a certain temperature (22°C) and must last for 6 weeks (Hall & Cherry 1993). Planting time and varietal selection can also affect the amount of damage that is incurred. Planting soon after oviposition may reduce damage because small wireworms are less likely to damage germinating sugarcane and this time period corresponds with a warmer time of the year which greatly speeds germination and emergence (Ingram et al. 1950). Adult *M. communis* are most numerous during Apr to Aug with peak oviposition in May to Jun (Cherry & Hall 1986). Application of insecticide soon after peak oviposition may be more effective because young wireworms may be more susceptible to insecticides (Genung 1972). However, this tactic is of little use in most of the sugarcane growing region as it is too wet to plant until Oct. Certain varieties avoid damage by germinating quickly (Hall 2001). Stand losses are greatest when wireworms eat the buds before germination (Hall 1985).

Only 2 insecticides, ethoprop and phorate, are currently registered for wireworm control in Florida sugarcane. Current chemicals will not kill every wireworm (Nuessly et al. 2007). Stand was reported to decline by 7% per wireworm per 1.5 m of row and yield was reported to decline by 3.8% per wireworm per 1.5 m of row (Hall 1990). While Hall (2001) reported that the threshold for treatment might be as low as 2610 wireworms per hectare, current studies indicate that this level of infestation may be well below what is needed to cause economical damage (N.A.L., unpublished data). Even in studies by Hall (1990), 17,600 to 35,200 wireworms per hectare were required to produce statistically significant stand and yield loss. Sugarcane has the ability to compensate for stand loss by tillering, with certain varieties tillering more profusely than others; therefore, sugarcane can withstand some degree of early stand loss.

Harris (1972) outlines how pesticide biological activity in the soil is affected by a number of chemical and environmental factors. Chemical factors that affect the biological activity of an insecticide include pesticide toxicity to the target organism, insecticide volatility, insecticide half-life, solubility of the insecticide, and adsorption characteristics of the insecticide. Soil factors that affect pesticide effectiveness are texture, structure, organic matter, moisture, pH, and temperature. A soil-dwelling insect must come into contact with a toxic dose of insecticide to be killed.

Most (75%) sugarcane in Florida is grown on histosols (referred to as muck soils), while the remainder is grown in a mixture of spodosols, alfisols, and entisols (referred to as sandy soils) that are typical of the flatwoods of central and southern Florida. Despite the obvious differences between mucks and sandy soils, such as organic matter content and water holding capacity, there are no differences in recommended insecticide rates for use on either soil. For example, the Thimet 20G (phorate, AMVAC, Los Angeles, CA) label recommends the use of 16.4 to 21.9 kg/hectare (14.6 to 19.5 lb/acre) and the Mocap 20G (ethoprop, Bayer CropScience, Research Triangle Park, NC) label recommends 16.8 to 22.4 kg/hectare (15 to 20 lb/acre), regardless of soil type. Cherry & Raid (1999) found that it took 7 times as much chemical to kill wireworms in a muck soil versus a sandy soil. The only other guidance given for insecticide use is that the applicator should use the lower rate for lighter wireworm infestations. Many growers do not treat sugarcane growing on sandy soil due to the belief that wireworms are not problematic on sandy soils; however, Cherry & Stansly (2007) reported that while there were fewer wireworms in sandy soils, they did occasionally reach populations high enough to warrant treatment.

Based on the characteristics of the insecticides in Table 1, phorate is more tightly bound to soil, has a longer half-life, and is less soluble than ethoprop. Phorate should be less available to the insect and less prone to leaching, while ethoprop should be more available to the insect and more prone to leaching. Given their similar toxicities, one would expect ethoprop to be a more effective insecticide for wireworm control. However,

TABLE 1. CHARACTERISTICS OF PESTICIDES USED FOR WIREWORM CONTROL IN FLORIDA SUGARCANE.

| Name and formulation | Active ingredient | Half-life[1] (days) | Koc[1] (mg/kg) | Solubility[1] (mg/L) | Toxicity (LD50)[2] µg/wireworm) |
|---|---|---|---|---|---|
| Thimet 20G | phorate | 60 | 1000 | 22 | 0.64-1.03 |
| Mocap 20G | ethoprop | 25 | 70 | 750 | 0.44-2.00 |

[1]Vogue et al. 1994.
[2]Cherry & Hall 1985.

Cherry & Raid (1999) determined that phorate was the more effective insecticide. The purpose of this research was to evaluate the effectiveness of reduced rates of ethoprop and phorate in killing wireworms and reducing damage to sugarcane in soils typical for Florida sugarcane production.

## Materials and Methods

Simulated field experiments were used to evaluate insecticides for wireworm control and sugarcane protection in different soil types, because uniform natural infestations in commercial or experimental fields could not be relied upon. Artificially infesting a natural field with 3.33 wireworms per linear meter of row did not cause enough damage to be detected (N.A.L., unpublished data). It is possible that a greater level of infestation may have caused recognizable damage; however, the sheer quantity of wireworms required for such an experiment (3000-5000 wireworms) could not be procured. A simulated field experiment done in a greenhouse allowed for regulation of several otherwise uncontrollable variables such as temperature, the number of stalks and buds, soil moisture, and the number of wireworms. Experimental units for the tests were 18.9-L (5-gal) buckets filled with the specific soil type and planted with sugarcane variety CP89-2143 seed pieces. Sugarcane stalks were harvested at the EREC 3 d prior to setting up each experiment. Seed pieces with live, undamaged buds (eyes) were taken from the center third of each stalk. Buckets were infested with *M. communis* larvae collected from sugarcane fields within the Everglades Agricultural Area by overturning stools between Oct and Jan. Collected larvae were maintained in buckets of muck soil on a carrot diet within an insectory room at 27°C and 14:10 L:D h photoperiod until used.

### Soil and Rate Interaction Experiment

The experiment was conducted within a fan and pad cooled greenhouse with temperature loosely maintained between 20° and 30°C from 12 Feb 2007 to 13 Apr 2007 in a histosol and spodosol. The histosol used was Dania Muck (Euic, hyperthermic, shallow Lithic Haplosaprists, pH 7.4, 65% organic matter) and the spodosol used was Immokalee Fine Sand (Sandy, siliceous, hyperthermic Arenic Alaquods, pH 7.8, 1.9% organic matter). Phorate (Thimet 20G) at 62% to 100% of the maximum label rate: 13.6, 16.4, 19.2, and 21.9 kg/hectare (12.1, 14.6, 17.1, and 19.5 lb/acre), a no-chemical control and a no-wireworm control were tested. To set up the experimental units, soil was first added to each bucket and compacted to field density. This was accomplished by adding 7.25 kg of Dania Muck or 13.36 kg of Immokalee Fine Sand to the bucket and then tamping and packing the soil to 17.8 cm below the rim of each bucket to achieve field bulk densities of 0.76 g/cm$^3$ and 1.55 g/cm$^3$, respectively. Ten late-instar *M. communis* larvae (>1.75 cm) were then added to the soil in each bucket 2 d prior to planting the sugarcane seed pieces. Seed pieces were immersed in hot water (40°C) for 30 min immediately before planting to treat for pineapple disease (*Ceratocystis paradoxa*) and red rot disease (*Glomerella tucumanensis*). Three seed pieces 24-29 cm long, with 2 to 3 nodes per seed piece (total of 7 to 8 nodes per bucket) were placed in the buckets and then the granular insecticide was applied. Additional soil was added over the seed pieces and compacted to field bulk density 2.5 cm from the lip of the bucket so that the planting depth was 15.2 cm. Ten buckets were set up for each of the treatments.

Shoot counts were conducted weekly after shoot emergence to keep track of dead hearts, damaged shoots, and healthy shoots. After 60 d, plant height was measured from the soil surface to the top visible dewlap of the tallest shoot in each bucket. The buckets were then upended and the soil in each bucket extensively searched for wireworm larvae, pupae, and adults. Plants were examined for wireworm–damaged seed pieces, eyes, and shoots. An eye, shoot, or tiller was counted as damaged if there was evidence of wireworm feeding. Seed pieces were each rated on the following rating scale: 0 = no damage, 1 = surface feeding only, 2 = 1 hole in the seed piece, 3 = 2 holes in the seed piece, and 4 = 3 or more holes in the seed piece. After examination, plants were dried and dry weights were measured for roots, shoots, and seed pieces.

### Chemical and Rate Interaction Experiment

Wireworm control and sugarcane damage was compared between 24 Jan 2008 and 24 Mar, 2008 at 25, 50, 75, and 100% of the maximum labeled rates for phorate (Thimet 20G) and ethoprop (Mocap 20G) in a Lauderhill Muck (euic, hyperthermic shallow Lithic Haplosaprist, pH 6.2, 60% organic matter). Ten treatments were evaluated, including phorate at 5.5, 10.9, 16.4, and 21.9 kg/ha (4.9, 9.8, 14.6, and 19.5 lb/acre), ethoprop at 5.6, 11.2, 16.8, and 22.4 kg/ha (5, 10, 15, 20 lb/acre), a no-chemical control, and a no-wireworm control. Experimental units were set up as before, except that seed pieces were treated immediately prior to planting in an attempt to reduce infection by pineapple disease and red rot disease by soaking for 1 h in a 0.59% solution of propiconozole (Tilt, Syngenta, Greensboro, NC). Ten buckets were set up for each treatment.

In the soil and rate interaction experiment, soil type, chemical rate, and the interaction of these factors were modeled to evaluate their effects on seed piece damage rating, wireworm survival, and percentage stand loss. Analysis of variance was conducted and least squared means were generated with JMP 6 (SAS Institute 2005). Treatment rate of each chemical was modeled by regression analysis to evaluate its effect on seed piece damage rating, wireworm survival, and percentage stand loss in the chemical and rate interaction experiment. An LSD test was used for means comparisons where ANOVA determined that a factor was a significant source of model variation. The no-wireworm control data were removed from all statistical analyses evaluating wireworm control since there was no variation.

## Results and Discussion

### Soil and Rate Interaction

Numbers of surviving *M. communis* were not significantly affected by soil type ($df$ = 1, 8; $F$ = 3.4021; $P$ = 0.0684). While all treatments reduced *M. communis* numbers significantly, none were able to completely eliminate *M. communis* (Table 2). There was not an apparent rate response in the Dania Muck as the lowest rate was statistically equivalent to the highest rate. While *M. communis* numbers did decline with increased rates of insecticide, the decline was not significant ($F$ = 2.9477; $P$ = 0.0941; $r^2$ = 0.0720). The soil and chemical interaction term was not significant ($df$ = 4, 8; $F$ = 0.8093; $P$ = 0.5224).

Seed piece damage ratings (Table 3) were lower in the Immokalee Fine Sand than in the Dania Muck ($df$ = 1, 8; $F$ = 12.36; $P$ = 0.0007). While there was separation among the various rates of phorate in the Dania Muck, there was no clear rate response as the lowest rate was statistically equivalent to the highest rate ($F$ = 2.4503; $P$ = 0.1258; $r^2$ = 0.06). The soil and insecticide interaction was not significant ($df$ = 4, 8; $F$ = 1.3049; $P$ = 0.2742).

Percentage stand loss (Table 4) was similar in the Dania Muck and the Immokalee Fine Sand ($df$ = 1, 8; $F$ = 3.194; $P$ = 0.0774). The addition of phorate reduced percentage stand loss in both soils. In both the Dania Muck ($F$ = 8.8596; $P$ = 0.0051; $r^2$ = 0.1890) and the Immokalee Fine Sand ($F$ = 6.8608; $P$ = 0.0126; $r^2$ = 0.15), a rate response to increasing rates of phorate was apparent with decreasing rates of phorate resulting in increasing percentages of percentage stand loss. Despite a significant regression model for both soils, the model only explained a small fraction of the variability. In the Dania Muck the mean decrease in stand loss per 2.8 kg/ha increase in rate was 3.5%. In the Immokalee Fine Sand, the rate response was dampened and leveled off. The increase from 13.6 kg/ha to 16.4 kg/ha in the Immokalee Fine Sand decreased percentage stand loss by 52%, the increase from 16.4 kg/ha to 19.2 kg/ha decreased percentage stand loss 57%. The final increase from 19.2 kg/ha to 21.9 kg/ha only resulted in a further 38% reduction. The soil and insecticide interaction was not significant ($df$ = 4, 8; $F$ = 0.2919; $P$ = 0.8826).

Table 2. Mean (± SEM) number of surviving wireworms per bucket 60 d after planting.

| Treatment | Rate (kg/ha) | Dania Muck | Immokalee Fine Sand |
|---|---|---|---|
| no chemicals | 0 | 9.2 ± 0.2 A | 9.3 ± 0.5 A |
| phorate | 13.6 | 4.4 ± 0.4 B | 5.0 ± 0.5 B |
| phorate | 16.4 | 3.1 ± 0.4 C | 4.2 ± 0.5 B |
| phorate | 19.2 | 2.9 ± 0.6 C | 4.1 ± 0.6 B |
| phorate | 21.9 | 3.9 ± 0.4 BC | 3.7 ± 0.5 B |
| | | $df$ 4, 45; $F$ = 36.43; $P$ < 0.0001 | $df$ 4, 45; $F$ = 19.21; $P$ < 0.0001 |

Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$).

Table 3. Mean (± SEM) seed piece damage rating per bucket 60 d after planting.

| Treatment | Rate (kg/ha) | Dania Muck | Immokalee Fine Sand |
|---|---|---|---|
| no chemicals | 0 | 2.0 ± 0.2 A | 1.6 ± 0.3 A |
| phorate | 13.6 | 0.5 ± 0.3 C | 0.1 ± 0.1 B |
| phorate | 16.4 | 1.0 ± 0.2 B | 0.2 ± 0.1 B |
| phorate | 19.2 | 0.6 ± 0.2 BC | 0.1 ± 0.1 B |
| phorate | 21.9 | 0.1 ± 0.1 C | 0.1 ± 0.1 B |
| | | $df$ 4, 45; $F$ = 13.55; $P$ < 0.0001 | $df$ 4, 45; $F$ = 17.37; $P$ < 0.0001 |

Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$).

TABLE 4. MEAN (± SEM) PERCENTAGE STAND LOSS PER BUCKET 60 D AFTER PLANTING.

| Treatment | Rate (kg/ha) | Dania Muck | Immokalee Fine Sand |
|---|---|---|---|
| no chemicals | 0 | 55.7 ± 6.5 A | 47.6 ± 6.6 A |
| phorate | 13.6 | 12.0 ± 4.2 B | 7.7 ± 3.4 B |
| phorate | 16.4 | 8.0 ± 2.2 B | 3.7 ± 1.4 B |
| phorate | 19.2 | 4.8 ± 1.8 B | 1.6 ± 1.1 B |
| phorate | 21.9 | 1.5 ± 1.5 B | 1.0 ± 0.7 B |
| | | *df* 4, 45; *F* = 35.42; *P* < 0.0001 | *df* 4, 45; *F* = 32.44; *P* < 0.0001 |

Means within a column followed by the same letter are not significantly different (LSD, $P \leq 0.05$).

Chemical and Rate Interaction

All ethoprop and phorate treatments had significantly fewer surviving wireworms than the untreated check (Table 5). Only the high rate of ethoprop performed as well as the phorate treatments. Ethoprop did show a significant rate response with progressively higher rates resulting in fewer surviving *M. communis* ($F = 26.2909$; $P < 0.0001$; $r^2 = 0.4089$). There was a 20-40% drop in wireworm mortality with each 5.5 kg/ha reduction in ethoprop rate. There was no rate response with phorate, and all rates dropped the surviving *M. communis* counts to around one per bucket ($F = 0.0383$; $P = 0.8459$; $r^2 = 0.0010$).

Phorate application resulted in a mean seed piece damage rating of 0.16, which was significantly lower ($df = 1, 78$; $F = 27.068$; $P < 0.0001$) than ethoprop which had an average seed piece rating of 0.95. The 22.4 kg/ha rate of ethoprop did as well as all rates of phorate (Table 5). Ethoprop showed a distinct rate response with decreased rates leading to increased seed piece damage ($F = 47.1636$; $P = < 0.0001$; $r^2 = 0.5538$). There was a 233% increase in the seed piece damage rating between the 11.2 kg/ha and 5.6 kg/ha ethoprop rates. Phorate did not show a rate response for seed piece damage at the rates tested ($F = 1.5024$; $P = 0.2278$; $r^2 = 0.0380$).

Percentage stand loss is a measure of the percentage of damaged eyes, shoots, and tillers. Phorate had less stand loss than ethoprop (Table 5). There was a rate response for ethoprop with increases in stand loss equal to or greater than 50% for each 5.5 kg/ha reduction below the 16.8 kg/ha rate ($F = 24.4167$; $P < 0.0001$; $r^2 = 0.3912$). A similar rate response was not detected for phorate ($F = 3.0363$; $P = 0.0895$; $r^2 = 0.0740$).

## DISCUSSION

Soil type, chemical, and rate interact to determine the efficacy of the insecticide. The toxic doses of both phorate and ethoprop to *M. communis* were determined previously by Cherry & Hall (1985); however, little research has been done to investigate how the soil interacts with phorate and ethoprop to eventually deliver a toxic dose. The results of the soil-rate interaction experiment

TABLE 5. MEAN (± SEM) DATA FOR SURVIVING *M. COMMUNIS*, SEED PIECE DAMAGE RATING, AND PERCENTAGE STAND LOSS PER BUCKET 60 D AFTER PLANTING IN LAUDERHILL MUCK.

| Treatment | Rate (kg/ha) | Surviving *M. communis* | Seed piece damage rating[1] | Percentage stand loss |
|---|---|---|---|---|
| no chemicals | 0.0 | 8.4 ± 0.2 A | 2.8 ± 0.1 A | 60.0 ± 5.5 A |
| ethoprop | 5.6 | 5.8 ± 0.3 B | 2.1 ± 0.3 B | 40.5 ± 4.5 B |
| ethoprop | 11.2 | 3.5 ± 0.4 C | 0.9 ± 0.2 C | 24.1 ± 6.3 C |
| ethoprop | 16.8 | 2.8 ± 0.3 CD | 0.6 ± 0.1 CD | 14.9 ± 2.8 CD |
| ethoprop | 22.4 | 1.9 ± 0.3 DE | 0.3 ± 0.1 DE | 11.8 ± 2.3 DE |
| phorate | 5.5 | 1.0 ± 0.1 E | 0.3 ± 0.1 DE | 4.9 ± 1.5 EF |
| phorate | 10.9 | 1.1 ± 0.2 E | 0.0 ± 0.0 E | 4.2 ± 1.8 EF |
| phorate | 16.4 | 1.1 ± 0.3 E | 0.3 ± 0.2 DE | 1.6 ± 0.8 F |
| phorate | 21.9 | 0.9 ± 0.2 E | 0.0 ± 0.0 E | 2.2 ± 1.2 EF |
| | | *df* 8, 81; *F* = 34.30; *P* < 0.0001 | *df* 8, 81; *F* = 44.10; *P* < 0.0001 | *df* 8, 81; *F* = 32.59; *P* < 0.0001 |

Means within a column followed by the same letter are significantly different (LSD, $P \leq 0.05$).

[1]Seed piece damage rating scale: 0 = no damage, 1 = surface feeding only, 2 = 1 hole in the seed piece, 3 = 2 holes in the seed piece, and 4 = 3 or more holes in the seed piece.

suggest that a reduced rate of phorate is effective at delivering a toxic dose of insecticide in both muck and sand soils. In the model, the soil and insecticide rate interaction term was never significant for any of the response variables. There were similar levels of mortality in both soils even though the seed piece damage rating and percentage stand loss in the Immokalee Fine Sand were numerically lower. This may suggest that activity was more rapid in the Immokalee Fine Sand or perhaps the chemical diffused through the sandy soil causing mortality before damage could be done.

In the chemical-rate interaction experiment, a wider range of rates were used to better detect a rate response. All rates of phorate caused mortality of nearly 90%, which was much higher than the observed mortality in the soil-rate interaction experiment where mean mortality was only around 60% across all soil types and treatments. In the soil-rate experiment, many *M. communis* larvae pupated and finished development. In the soil-rate experiment more pupae and adults were found than in the chemical and rate experiment, so it is possible that some larvae were not ever exposed to the insecticide. The soil pH in the chemical and insecticide rate interaction experiment was lower (Lauderhill Muck, 6.2) than both of the soils in the soil and insecticide rate interaction experiment (Dania Muck 7.8; Immokalee Fine Sand, 7.2). Harris (1972) indicated that some soil insecticides may have reduced activity in a high pH environment due to alkaline hydrolysis.

None of the rates of ethoprop caused 90% mortality and decreasing rates caused increased survivorship. Despite similar levels of toxicity, ethoprop was less able to kill *M. communis.* The chemical characteristics indicate that phorate will be bound to the soil and inactivated more effectively than ethoprop; however, mortality numbers indicate that perhaps something more than binding characteristics were at play. Phorate does have a longer half-life than ethoprop, so it is possible that a lethal dose was available for a longer time. These experiments do suggest that the label rates for phorate may be supraoptimal for controlling wireworms in sugarcane.

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