Improved Chemical Protection of Sorghum Seed and Seedlings from Insect Pests in Honduras[1]

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ABSTRACT

Insect pests are a major constraint to sorghum, *Sorghum bicolor* (L.) Moench, production in southern Honduras. This study was conducted to compare the efficacy of insecticides for protecting sorghum seed and seedlings. The insecticide furathiocarb was tested as a seed treatment (Promet 400 CS®) and as soil treatment (Deltanet 10G®) at planting; terbuphos (Counter 10G®) and carbofuran (Furadan 10G®) were tested as soil treatments, and kerosene as a seed treatment. Damage to the seed was principally caused by wireworms and ants, whereas damage to seedling foliage was caused by the fall armyworm, *Spodoptera frugiperda* (J. E. Smith). All insecticide treatments resulted in significantly better plant stands 20 d post-emergence than the untreated stands. The effectiveness of kerosene in protecting seed and seedlings was negligible. Furathiocarb seed treatment (50 g ai/kg seed) and granular terbuphos provided significant control of all three insect pests; granular carbofuran did not protect the seed from removal by ants. Furathiocarb was as good as or better than the other, more toxic insecticides. Commercial application of furathiocarb to seed is suggested to extend the benefits of this product to farmers who normally do not take precautions to protect sorghum seed and seedlings from insect attack.

Key words: *S. bicolor*, chemical protection, seed pests, wireworms, ants, fall armyworm, *S. frugiperda*.

RESUMEN

Los insectos-plaga limitan la producción del sorgo, *Sorghum bicolor* (L.) Moench, en el sur de Honduras. En este estudio se compara la eficacia de los insecticidas en la protección de semillas y plántulas de sorgo. El insecticida furatiocarb fue evaluado como tratamiento para la semilla (Promet 400 CS®) y para el suelo (Deltanet 10G®) en el momento de la siembra; terbufos (Counter 10G®) y carbofurán (Furadán 10G®) se evaluaron como tratamientos para el suelo, y el querosén para la semilla. El daño a la semilla lo provocó, principalmente, el gusano alambre y las hormigas, mientras que el gusano cogollero, *Spodoptera frugiperda* (J.E. Smith), causó daño al follaje de las plántulas. Todas las aplicaciones de insecticidas causaron una mejor población de plantas, 20 d posemergencia, en comparación con el testigo. La efectividad de querosén para proteger la semilla y la plántula fue insignificante. Furatiocarb como tratamiento para la semilla (50 g ia/kg de semilla) y terbufos en una formulación granular lograron un control significativo de las tres plagas; carbofuran en formulación granular no protegió la semilla que fue removida por las hormigas. Furatiocarb funcionó mejor que los otros insecticidas más tóxicos. Por eso, se recomiendan aplicaciones comerciales de furatiocarb a la semilla para extender los beneficios de este producto a los agricultores, quienes, normalmente, no toman precauciones para proteger la semilla y la plántula del sorgo de los insectos.

INTRODUCTION

Sorghum, *Sorghum bicolor* (L.) Moench, is the third most important basic grain produced in Honduras (Hond.Secretaría de Planificación 1987). Between 1983-1988, 52% of sorghum produced in Honduras came from the southern area of the country; 95% of this came from local landraces called "maicillos" grown on small farms (Hond.Ministerio de Economía 1990). The area planted to sorghum showed a slight increase from approximately 52 800 ha in the 1970s to 54 000 ha in the 1980s. However, average yield per hectare dropped from 0.93 to 0.85 metric tons during this time, with an annual decreasing rate of 2.3% (García 1988; Hond.Ministerio de Economía 1990). This yield reduction is attributed to several factors, but the most common cited is the increasing pest population. Although acreage of high-yielding sorghum hybrids

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has increased six-fold (from 2000 ha to 12 000 ha) in the past four years (Gómez, personal communication), maximum yield potential has not been achieved, in part due to the lack of good early season pest control.

Wireworms account for up to 10% sorghum seed loss in southern Honduras (Portillo 1991). A lepidopterous pest complex, consisting of four lepidopterous pests and locally called *langosta*, can cause sorghum seedling losses as high as 20% during the first three weeks of crop growth (Portillo 1991; Portillo *et al.* 1991).

To prevent damage to sorghum seed and seedlings by insect pests, some farmers in southern Honduras mix granular insecticides with their sorghum or maize, *Zea mays* L., seed at planting. Other, more resource-poor farmers commonly soak their seed in kerosene prior to planting to control insect pests. Some insecticides with low mammalian LD_{50}s pose high risks for dermal intoxication when planting by hand. Farmers lacking the proper equipment to apply these products often do not take measures to protect themselves. However, seed treatment with insecticides having higher LD_{50}s could be safer and more cost-effective for farmers, as well as less damaging to the ecosystem. These products, in addition to requiring higher lethal doses for mammals, also persist for shorter periods of time in the soil and are more insect species-specific in their range of action.

The objective of this study was to compare the efficacy of some frequently used granular insecticides with new granular and seed treatment insecticides on sorghum seed and seedling insect pests in Honduras.

MATERIALS AND METHODS

This study was conducted on-farm at two locations in southern Honduras in 1989. One site was near El Conchal, is located on the Pacific coastal plain (near sea level, 13° 31' N 87° 22' W) near the border with El Salvador in the Department of Valle. The other site was at the La Lujosa Agricultural Experiment Station of the Ministry of Natural Resources (13° 31' N 87° 43' W), located 15 km west of the city of Choluteca in the Department of Choluteca. These locations were selected to contrast low tillage conditions in El Conchal with conventional tillage at La Lujosa.

Plots at El Conchal were prepared for planting by using ox–pulled plows to break the soil and to make the seed furrow. The planting date at El Conchal was May 29. Plots at La Lujosa were prepared with a tractor and the field was disked twice before laying up beds with a seed furrow. This field was planted June 9. A sorghum hybrid, "Catracho," with pedigree (AT x 623 * CS3541 sel.), was planted in pure stand. Agricultural practices were the same in both sites with exception to land preparation. Seeds was planted in hills in rows 0.8 m apart. Treatments were: furathiocarb (Promet ® 400 CS) at 25, 50, and 75 ml per kg of seed; furathiocarb (Deltanet ® 10G) at 0.5 g per hill; carbofuran (Furadan ® 10G) at 1 g per hill; terbuphos (Counter ®) 10G at 0.5 g per hill; kerosene at 80 ml per kg of seed; and untreated seed.

Treatments were arranged in a randomized complete block design and replicated four times at each location. Furathiocarb was a new product introduced on the market at the time of the study, and both the liquid seed treatment and granular formulation were tested. Three seed treatments of furathiocarb were tested in order to determine the most effective and economic application rate for sorghum. Kerosene is commonly used as a low-cost seed protectant by some subsistence farmers in Honduras. Trabanino *et al.* (1987) reported significantly fewer sorghum seeds removed by ants when seeds were treated with kerosene than when the seeds were untreated. However, no advantages were found in protecting seedling plants. Thus, kerosene was included in this study as a treatment representing a traditional planting practice used by subsistence farmers.

Treatment plots were 6 m long (13 hills in a row) and four rows wide, for a total area of 19.2 m^2. Ten seeds were planted in each hill. Seed to be planted per hill were counted and placed in small plastic bags before planting to ensure that the exact number was planted. Furathiocarb was applied to the seed by mixing the liquid insecticide and the seed in 5 lb plastic bags. Kerosene was applied to the seeds in the bags using a dropper applicator immediately prior to planting. Granular insecticides were weighed to the appropriate dose per hill, placed in plastic bags apart from the seed until planting, deposited in respective treatment hills, and covered with soil. Seeds were planted over the insecticide treatment at a depth of 5 cm, then covered with soil.

Seeds or plants within treatment plots were sampled at five different stages of development after emergence. Four hills in the two center rows of each plot were selected at random and sampled on each date. The first sample (preemergence) was taken 5 d after planting. The other samples were taken postemergence and observations included number of plants per hill, plant height (measured from soil line to the tip of last leaf blade at El Conchal and to bottom of the whorl at La Lujosa) and number of leaves per plant (both with and without collar) at 20 d. Number of plants infested by *S. frugiperda* (J.E. Smith) was recorded at 5, 10, 15, and 20 d after emergence.

The data from each test location were analyzed separately. A two-way analysis of variance was performed on each variable and means were separated with Tukey's (HSD) test using Statistical Analysis Software (Sas Institute 1985; Steel and Torrie 1985). Percentage data were transformed using the arcsine of the square root transformation prior to analysis. Percentages of plants infested with *S. frugiperda* were analyzed using mean infestation for the four dates sampled.

RESULTS AND DISCUSSION

Most of the seed had emerged five days after planting at both locations. The percentage of seed which lacked vigor (pool average at El Conchal = 8% and at La Lujosa = 3.4%) or damaged by fungi (pooled average at El Conchal = 0.62% and at La Lujosa = 0.5%) was similar among treatments within each location. This indicates that the granular and seed treatments used in this study did not have harmful affects on seed germination. Seed treated with the two highest doses of furathiocarb (75 and 50 ml per kg of seed) had the highest percentage of germinated seeds at both locations; however, these two doses of furathiocarb were not significantly ($p=0.05$) better than any of the other treatments except granular furathiocarb, kerosene and untreated seed at El Conchal, and only kerosene and untreated seed at La Lujosa. Kerosene and untreated plots had the lowest number of seed germinated compared to other treatment plots at El Conchal; at La Lujosa, the kerosene treatment plots did not differ significantly in percentage of seed germinated when compared with carbofuran and granular furathiocarb treatment plots or untreated plots.

Partially destroyed embryos of ungerminated seed suggested that wireworms (Coleoptera) were responsible for this damage. Species of wireworms reported in sorghum and maize fields in southern Honduras include *Aeolus* sp., *Dipropus* sp., and *Conoderus* spp. in the family Elateridae and *Epitragus* sp. in the family Tenebrionidae (Portillo 1991; Trabanino *et al.* 1990). Untreated seed and seed treated with granular furathiocarb or kerosene had the highest percentage of damage by wireworms at El Conchal (low tillage field) (Table 1). Wireworm damage was minimal at La Lujosa (conven-

Table 1. Effect of chemical treatment on sorghum seed survival five days after planting in two locations in southern Honduras, 1989.

Treatment		% Germinated Seed		% Non-Germinated Seed[3]		% Non Germinated Seed[4]		% Seed Damaged Wireworms[5]		% Missing Seed[6]	
Material	Form (Dose)[1]	Loc 1[2]	Loc 2	Loc 1	Loc 2	Loc 1	Loc 2	Loc 1	Loc 2	Loc 1	Loc 2
Furathiocarb	400 CS (75 ml)	89 ± 13 a	93 ± 7 a[7]	4 ± 8 a	2 ± 6 a	1 ± 3 a	1 ± 2 a	0 ± 0 a	0 ± 0 a	6 ± 8 ab	4 ± 6 a
Furathiocarb	400 CS (50 ml)	86 ± 15 a	89 ± 11 a	8 ± 9 a	4 ± 6 a	1 ± 3 a	0 ± 0 a	0 ± 0 a	1 ± 2 a	4 ± 7 a	7 ± 12 a
Furathiocarb	400 CS (25 ml)	70 ± 16 ab	91 ± 11 a	10 ± 11 a	6 ± 10 a	1 ± 3 a	1 ± 2 a	2 ± 5 a	1 ± 2 a	17 ± 12 bcd	2 ± 4 a
Furathiocarb	10 G (0.5 g)	56 ± 27 bc	81 ± 16 ab	9 ± 14 a	0 ± 0 a	0 ± 0 a	1 ± 2 a	16 ± 23 bc	1 ± 2 a	18 ± 22 abcd	18 ± 17 ab
Terbuphos	10 G (0.5 g)	74 ± 25 ab	88 ± 17 a	9 ± 10 a	5 ± 14 a	0 ± 0 a	0 ± 0 a	6 ± 18 ab	0 ± 0 a	11 ± 13 abc	7 ± 6 ab
Carbofuran	10 G (1 g)	68 ± 18 ab	77 ± 22 ab	6 ± 7 a	6 ± 15 a	1 ± 2 a	0 ± 0 a	5 ± 8 ab	3 ± 5 a	20 ± 13 cd	14 ± 19 ab
Kerosene	L (80 ml)	28 ± 25 d	58 ± 25 bc	11 ± 14 a	2 ± 7 a	1 ± 2 a	1 ± 2 a	26 ± 21 c	15 ± 24 b	34 ± 20 d	24 ± 14 bc
Untreated	——	37 ± 26 cd	51 ± 34 c	7 ± 12 a	2 ± 7 a	0 ± 0 a	0 ± 0 a	22 ± 17 c	3 ± 5 a	33 ± 20 d	44 ± 35 c

1 Dose in ml of product per kilogram of seed or grams of product per hill
2 Loc. 1 = Location 1 = El Conchal. Loc 2 = La Lujosa
3 Healthy but not germinated seed.
4 Seed damaged by fungi
5 Wireworms (Coleoptera: Elateridae, Tenebrionidae)
6 Mainly removed by ants and millipedes
7 Means ± SD followed by the same letter in the same column within the same location are not significantly different ($p=0.05$) by Tukey's (HSD) mean separation test (12)

tional tillage field) Interestingly, seed treated with kerosene had significantly more damage than the other treatments, including the untreated (Table 1) We can not explain this observation At low wireworm population, the damage by wireworms at this location was not significantly different in insecticide treatments compared to the untreated The low incidence of wireworms in the La Lujosa field may be related to soil preparation before planting This practice will destroy the damaging larval stages of the pest

Seed that were not accounted for (missing seed) at preemergence sample were considered to have been removed from the plots by ants and millipedes The tropical fire ant, *Solenopsis geminata* (F) (Hymenoptera: Formicidae), is the most common ant species in southern Honduras (Trabanino *et al.* 1990) Although *S. geminata* is reported to be an important predator of some insect pests like *S. frugiperda* (Sequeira 1987), a great portion of its diet consists of seed (Schinkel 1988). These ants are well adapted to the dry, hot conditions of southern Honduras where agricultural systems with small seeds like sorghum are abundant (Braulick *et al* 1998; Carroll and Risch 1984) Millipedes are also reported as a common pests of sorghum seed in southern Honduras, with densities up to 1 2 millipedes per m^2 of soil (14). Sequeira (1987) reported that millipedes tend to remove sorghum seed from the soil and eat them on the surface

At El Conchal, plots with sorghum seed treated with 50 ml or 75 ml of furathiocarb per kilogram of seed had the lowest percentage of missing seeds (Table 1) These treatment plots had significantly fewer seeds missing than the carbofuran, kerosene and untreated plots (Table 1). Terbuphos treatment plots had significantly fewer seeds missing than the kerosene and untreated plots, but terbuphos did not protect the seeds better than the other treatments. Although carbofuran, granular furathiocarb and the lowest dose of furathiocarb seed treatments had a lower percentage of seed missing than kerosene and untreated seed at El Conchal, the differences were not significant Except for kerosene, all treatment plots had significantly fewer seeds missing than the untreated plots at La Lujosa Results indicated that kerosene seed treatment did not provide significant reduction in seed damage or removal by wireworms and ants In general, there was a higher percentage of seed missing in treatment plots at El Conchal than at La Lujosa. Conventional tillage creates favorable conditions for ant colony spread (Risch and Carroll unp. data) However, interference with normal colony activities and planting soon after tillage may allow seed to germinate before ants recover from the disturbance, thus resulting in fewer missing seeds

The highest number of seedling plants per hill was obtained when seed were treated with furathiocarb or when granular terbuphos was used at El Conchal (Table 2) Only plots with seed treated with the two highest doses of furathiocarb had significantly more plants per hill than granular furathiocarb, carbofuran, kerosene, and untreated plots 5 d after seedling emergence Terbuphos plots had significantly more plants per hill at this time than kerosene and untreated plots By day 20 after seedling emergence, only the furathiocarb-(highest rate) treated plots had significantly more seedling plants per hill than the kerosene and untreated plots. The kerosene plots had significantly more plants per hill than the untreated plots at day 20 after seedling emergence The effects of the insecticides were different at La Lujosa 5 and 20 d after seedling emergence Kerosene and untreated plots had significantly fewer plants per hill than all other treatment plots and no significant differences in plants per hill were observed among the insecticide treatments At this location, kerosene plots were not better than untreated plots These results indicate that the effectiveness of the insecticides can vary according to insect pest pressure or other conditions as observed in data from the two locations of this test

Plant development, based on number of leaves per plant and plant height 20 days after emergence, appeared to be better when insecticides were used with the seed than when seed was untreated (Table 2). Although furathiocarb-treated seed and granular furathiocarb resulted in taller plants with more leaves in comparison with other treatments at planting at El Conchal, significant differences were not observed All treatments used to protect the sorghum seed and seedlings allowed plants to produce an equal number of leaves per plant and reach the same height by day 20 at the La Lujosa location Furathiocarb seed and granular treatment and terbuphos had significantly higher number of leaves per plant than the control at El Conchal, but only the highest dose of seed treated with furathiocarb had significantly more leaves per plant than the control at La Lujosa All treatments but kerosene had significantly higher plant height than the control in both locations

Columns followed by the same letter are not significantly (p=0 05) different according to Tukey's (HSD) mean separation test (Steel and Torrie 1980).

The percentage of plants infested with *S. frugiperda* from days 5 to 20 after seedling emergence at El Conchal showed that, although all treatment plots had lower infestations than untreated plots, the treatments used to protect the seed and subsequently the seedlings generally were not significantly different from the untreated (Fig. 1). Infestations at La Lujosa were too low for statistical analysis.

CONCLUSIONS

The best protection for sorghum seed against wireworm damage was obtained with furathiocarb seed treatment at 50 and 75 ml insecticide per kg of seed and terbuphos and carbofuran granules applied with the seed at planting. These four treatments resulted in significantly higher percentage of germinated seed than other test treatments. However, carbofuran did not provide similar protection from sorghum seed removal by ants. Furathiocarb-treated seed (50 and 75 ml/kg of seed) and terbuphos granules resulted in significantly fewer sorghum seeds removed by ants than other treatments.

Kerosene provided only limited protection to the seed, but this seed treatment may be an acceptable alternative under certain conditions for resource-poor farmers who can not afford to buy commercial insecticides. However, farmers should not be encouraged to use kerosene if they can afford to purchase commercial insecticides for protection of sorghum seed and seedlings. Although some levels of protection from insects were given to the sorghum seed by the insecticide treatments, only 70% of the planted seed in the best treatment became established as plants. This explains why

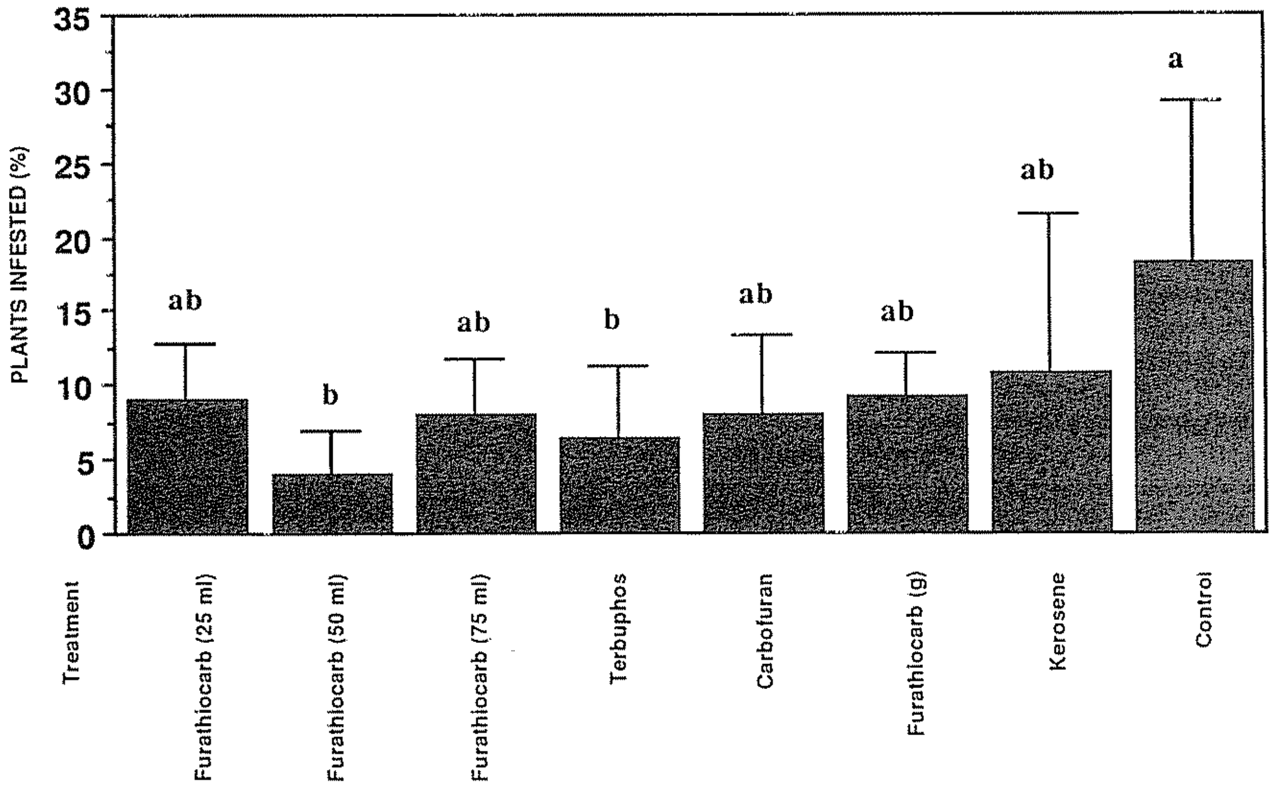

Fig. 1. Mean (±SD) percentage sorghum plants infested with *S. frugiperda* (pooled data 5, 10, 15 and 20 d post emergence) when treated with different seed and granular insecticides at El Conchal in southern Honduras, 1989.

most farmers in southern Honduras plant an average of 15 seed per hill (Dewalt and Dewalt 1982).

The insecticides applied at planting to protect the seed from insects may provide additional benefits in protecting seedlings from the *langosta*, the lepidopterous complex that attacks sorghum and corn crops in southern Honduras (Portillo *et al* 1991). This protection to the seedlings during early plant growth and development can be responsible for stand establishment and plant survival past the vulnerable and critical early plant growth stages.

The decision to use one of the test chemical insecticides over another should consider the effectiveness, safety and price of the product and its application. Terbuphos (4.5 -9.0 mg/kg oral and 1.1 mg/kg dermal LD_{50}) is more toxic than carbofuran (11 mg/kg oral LD_{50}) and furathiocarb (137 mg/kg oral LD_{50}). Considering the hand-planting methods used by resource-poor farmers, granular insecticides mixed with the seed present a high human safety risk. Carbofuran could be the choice of seed treatment by these farmers, given that it has a higher dermal LD_{50} (10, 200 mg/kg) than furathiocarb (2000 mg/kg). However, furathiocarb applied as sorghum seed treatment provided a higher level of insect control and could be the choice of insecticides for use by farmers with financial resources and equipment suitable for safe application.

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