Soil-Inhabiting Phytophagous Arthropod Pests in Intercropped Sorghum and Maize in Southern Honduras[1]

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ABSTRACT

Soil samples were taken to determine identities and composition of insects and other arthropods, excluding mites and springtails, in intercropped sorghum and maize fields on hillsides and plains in southern Honduras in 1985 and 1986. Elateridae (wireworms): Pyrophorinae (unidentified genus), Conoderinae *Conoderus* spp., *Aeolus* spp., Elaterinae *Dipropus* sp.; Scarabaeidae (white grubs): Dynastinae (unidentified genus), Melolonthinae *Phyllophaga* spp., *Diplotaxis* spp.; Chrysomelidae (rootworms): Eumolpinae and Galerucinae; and Diplopoda (millipedes) were among the most abundant arthropods found. In 1985, density of white grubs was higher on the plains in slash-and-burn fields without soil preparation than in slash-and-mulch fields with soil preparation. Wireworms, rootworms and millipedes were found at higher densities in slash-and-burn than in slash-and-mulch fields on both the plains and the hills and slash-and-burn fields on the hillside in 1986. White grub abundance did not appear to be affected by slash and burn practices. However, numbers of whitegrubs were lower following tillage practices in fields on the plains. Rootworms were found in higher numbers in fields on the plains than on hillsides. Increased numbers of arthropods in burned fields appeared to be related to their establishment in attractive, luxuriant regrowth vegetation.

COMPENDIO

Se tomaron muestras de suelo en campos de maíz y sorgo intercalados en campos de zonas planas y de ladera en el sur de Honduras en 1985 y 1986, para identificar los insectos y otros artrópodos. Los artrópodos encontrados, más abundantes fueron: Elateridae (gusano alambre): Pyrophrorinae (género sin identificar), Conoderinae *Conoderus* spp., *Aeolus* spp., Elaterinae *Dipropus* sp.; Scarabaeidae (gallina ciega): Dynastinae (género sin identificar), Melolonthinae *Phyllophaga* spp., *Diplotaxis* sp.; Chrysomelidae (larvas de tortuguilla): Eumolpinae y Galerucinae; y Diplopoda (milpies). Los números de gallina ciega fueron mayores en los campos planos con corte y quema sin preparación del suelo. Poblaciones de gusano alambre, larvas de tortuguilla y milpies se encontraron en mayor número en 1985, en los campos con corte y quema que en los campos con corte sin quema tanto en plano como en laderas; y en 1986 en los campos de laderas con corte y quema. Las prácticas de corte y quema no tuvieron efecto sobre la abundancia de la gallina ciega. Sin embargo, la preparación del suelo parece haber reducido el número de gallina ciega en los campos planos. Se encontraron larvas de tortuguilla en mayor número en los campos planos que en laderas. La quema pareció incrementar el número de artrópodos, debido posiblemente al abundante rebrote de la vegetación.

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INTRODUCTION

Maize (*Zea mays* L.), beans *Phaseolus vulgaris* L. and sorghum (*Sorghum bicolor* L. Moench), respectively, are the first, second, and third most widely grown crops in Honduras. Approximately 90% of the sorghum grown in Honduras is intercropped with maize (9). Many insect pest problems are associated with sorghum and maize production in southern Honduras. Agricultural extension workers and small farmers maintain that soil and early-season insect pests are principal constraints to production (pers. communication). However, little systematically collected information is available concerning the density and diversity of the arthropod species complex on these crops in the area.

White grubs (Scarabaeidae), rootworms (Chrysomelidae), and wireworms (Elateridae) are major soil inhabiting insect pests of sorghum and maize in Honduras and other Central American countries (4, 8, 9, 17, 18). Other reported soil inhabiting insect pests of sorghum and maize in the Latin American region include lesser cornstalk borer (*Elasmopalpus lignosellus* Zeller) (Pyralididae) (2, 24, 31), cutworms (Noctuidae) (24) and darkling beetles (Tenebrionidae) (37).

Studies of terrestrial arthropods have shown a variety of responses to habitat and population density changes caused by land preparation (4, 10, 11), but most indicate that cultivation reduces densities of soil arthropods. No-tillage systems have been reported to result in increased insect damage (11). Soil conditions (e.g., texture and moisture) and rainfall also influence population densities of soil arthropods (23, 36). Rubzova (34), Cancelado and Yonke (5), and Nagel (28) indicated that more insects were attracted to burned than unburned areas. Many species are attracted to burned fields because of rapid plant regrowth (14, 16, 19), whereas some species are driven out by burning (20, 33).

The objectives of this study were to identify the most abundant soil inhabiting insects or other phytophagous arthropods (excluding mites and springtails) and early season, seedling pests of sorghum and maize in different intercropped systems in southern Honduras and to elucidate the effects of certain cultural practices and topography on these pests in production fields.

MATERIALS AND METHODS

1985 Study

Location: This research was conducted in southern Honduras during the first crop cycle (May through July). Three areas representative of the southern region were selected with the help of Agricultural extension Service personnel of the Ministry of Natural Resources. With the help of the subsistence farmers, five production fields were selected in each of the three areas. The areas were Pavana (southcentral), and San Bernardo/Namasigue (southeast) in the Department of Choluteca, and Alianza (southwest) in the Department of Valle.

Treatments: The five systems or treatment combinations studied were: slash (stalks cut) and-burn on hillsides without soil preparation; slash-and-mulch (stalks and foliage on ground) on hillsides without soil preparation; slash-and-burn on plains with soil preparation; slash-and-burn on plains without soil preparation; and slash-and-mulch on plains with soil preparation. Soil preparation on hillsides is not practiced due to steep slopes, large numbers of rocks, and shallow soils. Each of the three areas represented one replication giving a total of three replications (areas) of each treatment combination. The fields were intercropped with sorghum and maize in the "casado", arrangement (sorghum and maize planted on same hill).

Sampling methods: An area in each of the study fields was divided into five plots of 25 x 25 m for sampling. Two soil samples were taken from each plot on four dates at intervals of nine to 15 days during the period from May 29 through July 23, 1985. A total of 10 samples per field were taken per date beginning 29 days after planting. One soil sample from each plot included a hill with sorghum and maize seeds or seedlings while the other sample was taken in the furrow or between hills and generally consisted of soil and possibly some non-crop plant material. Soil samples were taken using a 60 x 30 cm wooden rectangular frame with a metal edge that could be pushed 10 cm into the soil to prevent escape of fast crawling insects and other arthropods. The soil was removed to a depth of 10 cm using a 20 cm wide hoe. Each soil sample was placed into an individual plastic bag and taken to the laboratory at La Lujosa where it was held in a cool environment. Within three days, the soil was examined for insects and other soil inhabiting arthropods using a flotation technique. Each soil sample was deposited into a 38 l plastic bucket filled with 19 l of water. The soil and water were stirred intermittently by hand until the clumps of soil were disintegrated (about 15 min.). The suspension was then allowed to stand for five minutes after which a sieve (20 mesh) was used to collect the insects from the surface of the water. This process required about 20 minutes per sample. The complex of arthropods collected from each sample was placed into individual vials with 70% alcohol for subsequent identification.

Vouchers of all species were deposited in the Mississippi Entomological Museum at Mississippi State University.

Statistical design and analysis: The study was a split plot design with three replications. Fields with similar production methods in the three areas served as replications. The data were analyzed using analysis of variance, and means were separated with Student-Newman-Keuls' test

1986 Study

Location: The 1986 study was conducted only in the Alianza area due to constraints of time, labor, transportation, and other logistics. This area included both hillside and plains sites and was selected because higher soil arthropod densities and diversity were observed there than in the other two areas during 1985. Systems were reduced in number to the two most commonly used land-clearing practices, slash-and-burn, and slash-and-mulch.

Treatments: The four treatments were slash-and-burn and slash-and-mulch in fields on hillsides and on the plains. Six fields on hillsides were located in La Coyota, and six fields on the plains were located in El Conchal for a total of 12 fields. Three hillside and three plains fields were burned and three were not. The initial plan was for all fields to be planted with sorghum and maize. However, fields (representing both areas) were not planted with sorghum until the end of August because farmers feared crop loss due to an early season attack by an unidentified noctuid (or complex of species) known locally as "langosta". Thus, comparisons of densities and diversity of arthropods were made between fields planted with sorghum and maize in the "golpe alterno" arrangement (sorghum and maize on alternate hills) and fields planted with maize only.

Sampling methods: The sample area in each field was divided into five plots of 20 x 20 m. Two soil samples measuring 20 x 20 cm to a depth of 10 cm were taken at random from each plot using a 20 cm wide hoe. The samples were taken on eight dates over a period of 15 weeks from May 20 to August 20. Samples were taken at intervals of seven days during the first seven weeks and 20-25 days during the remaining eight weeks. Preplant soil samples were obtained in all fields on the plains. Crops were planted early in the La Coyota area (before selection of fields) due to rains in May, thus no preplant soil samples were obtained in fields on the hillsides.

Table 1. Distribution frequency of soil-inhabiting phytophagous arthropods in intercropped sorghum and maize fields during May-August in southern Honduras. 1985-1986.[1]

Group[2]	1985					1986			
	Hills no burn no prep.	Hills burn no. prep.	Plains no burn soil prep.	Plains burn no prep.	Plains burn soil prep.	Hills no burn no prep.	Hills burn no prep.	Plains no burn soil prep.	Plains burn soil prep.
Insecta									
White grubs (L)	•	•	•	•	•	•	•	•	•
Wireworms (L)	•	•	•	•	•	•	•	•	•
Lesser cornstalk borer (L)	•	•	•		•		•	•	•
Rootworms (L)	•	•	•	•	•	•	•	•	•
Ants (A)	•	•	•	•	•	•	•	•	•
Carabids (L)	•	•	•	•	•	•	•	•	•
Tenebrionidae (L-A)	•		•	•	•	•	•	•	•
Termites (A)		•	•			•	•	•	•
Curculionidae (L)	•	•	•	•	•	•	•	•	•
Negro bugs (A)	•			•		•			•
Cicadidae (L)						•			
Diplopoda									
Millipedes	•	•	•	•	•	•	•	•	•

1 All fields slashed (stalks cut); mulch remained on ground if field not burned. Fields on hillsides without soil preparation prior to planting; fields on plains with soil preparation, except where indicated in 1985

2 L = Larvae; A = Adult

Soil samples were placed in plastic bags and transported to the laboratory at El Zamorano where they were processed by visual search for arthropods Processing time was about 45 min. for each sample. Collected arthropods were submerged for 24 h in KAAD solution and then placed in 70% alcohol for subsequent identification

Statistical design and analysis: The study was a completely random design with three replications. The data were analyzed using least squares analysis of variance in a 2 x 2 factorial: means were separated with Student-Newman-Keuls' test

RESULTS AND DISCUSSION

1985 Study

Arthropods found in intercropped sorghum and maize fields in southern Honduras during 1985 are listed in Tables 1 and 2 Wireworms, white grubs, rootworms, lesser cornstalk borers, and millipedes were the most prevalent and were used in this study to compare arthropod numbers in the different cropping systems There was no significant location effect between densities of selected arthropods in samples taken in the bed (planting sites) and between the rows (little or no vegetation) However, the data suggest a trend that these arthropods congregated in the soil area surrounding the plant.

One might predict that density of soil-inhabiting phytophagous arthropods would be higher in areas where plant density is higher. As no differences were observed in numbers of the selected arthropods between samples in the bed and between the rows in this study, individuals of each species may be assumed to be equally distributed between these two sites. This may be due, in part, to the abundance of weeds present during most of the year. Weed density is reduced with cultivation (even in fields on hillsides where non-crop vegetation is removed prior to or at planting), but regrowth occurs during the growing season. This regrowth of non-crop plants serves as a food resource for the arthropods outside the seed bed area.

When the most prevalent arthropod groups were compared among the three sampled areas, insect densities did not differ significantly; but higher numbers of millipedes were found at Alianza than at Namasigue/San Bernardo (Table 3).

Numbers of wireworm, rootworm, and lesser cornstalk borer immatures and of millipedes were not significantly different among cultural systems However, white grub numbers were significantly higher in fields on the plains with slash-and-burn without soil preparation and slash-and-mulch with soil preparation than in plains fields with slash-and-burn with soil preparation and hillside fields (Table 4). The numbers of

Table 2. Soil-inhabiting phytophagous insects in intercropped sorghum and maize fields in southern Honduras, 1985-1986.

1985	1986
Scarabaeidae (white grubs)	Scarabaeidae
Phyllophaga sp	*Phyllophaga* sp.
Diplotaxis sp	Dynastinae, near *Cyclocephala*
	Dynastinae, near *Euetheola*
	Aphodiinae, near *Cylocephala* sp., Genus unknown
Elateridae (wireworms)	Elateridae
Dipropus sp	*Dipropus* sp
Conoderus spp. (2)	*Conoderus* sp.
	Aeolus spp (2)
Pyrophorinae, Pyrophorini (unidentified sp.)	Pyrophorinae, Pyrophorini (unidentified sp.)
Chrysomelidae (rootworms)	Chrysomelidae
Chrysomelinae, Genus unknown	Eumolpinae, Genus unknown
Eumolpinae, Genus unknown	Galerucinae, Genus unknown
Galerucinae, Genus unknown	
Carabidae (ground beetles)	Carabidae
Clivinia sp	*Clivinia* sp
Carabus sp.	Harpalinae, Amarini (unidentified sp.)
Amphasia sp	Harpalinae, Harpalini (unidentified sp.)
Cymindoidea sp	Harpalinae, Brachynini (unidentified sp.)
Harpalinae, Harpalini (unidentified sp.)	
Curculionidae (snout beetles)	Curculionidae
Sphenophorus sp.	near *Listronotus* sp
Baridinae, (unidentified sp.)	Baridinae, (unidentified sp.)
Formicidae (ants)	Formicidae
Solenopsis geminata (F.)	*Solenopsis geminata* (F.)
Pyralididae (lesser cornstalk borer)	Pyralididae
Elasmopalpus lignosellus (Zeller)	*Elasmopalpus lignosellus* (Zeller)
	Tenebronidae (darkling beetle)
	Epitragini, (unidentified sp.)
	Termitidae (termites)
	Amitermes sp

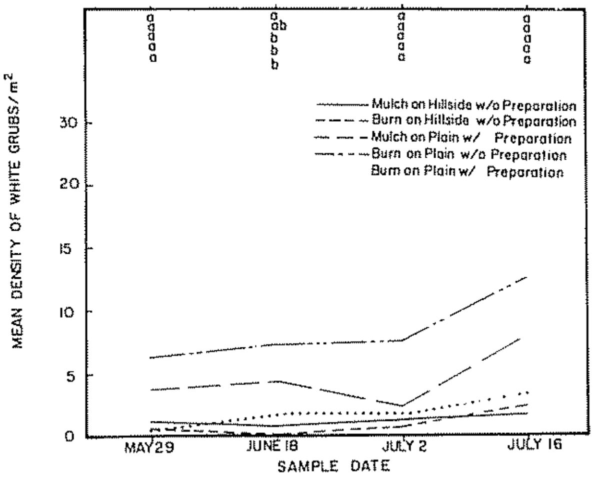

Fig. 1 Mean number of white grubs/m² in five different sorghum and maize intercropped systems in southern Honduras. 1985. Numbers on sample date with different letter (top of figure) in corresponding vertical position to treatment data are significantly different by Student-Newman Keuls' test (P ≤ 0.10)

white grubs increased in sampled fields from late May to mid-July (Fig. 1). Musick (27) and Gregory and Musick (11) reported that tillage decreased insect damage and that plant debris associated with reduced tillage provided an ideal environment for the development and survival of most insects that attack maize. Jarvis (15) indicated that a positive correlation exists between soil moisture and white grub numbers at different times of the year. More white grubs were found in undisturbed soils than in cultivated soils in the plains. Tillage practices have been reported to destroy large numbers of white grub larvae (10). Additionally, mechanical disturbance of the soil exposes grubs to parasites and predators (11) and to the sun to which they are very susceptible (4).

A significantly lower number of white grubs was found in burned fields than unburned fields in the plains when both systems received cultivation, suggesting that removal of debris by burning had an impact on their numbers (Table 4).

Hawkins (12) reported that soils of most hillside fields in Honduras show little horizon development, with parent material within 50 cm of the surface. The soils are low in organic matter and have low water holding capacity. Soils of hillside fields have higher sand and lower clay content than those in plains fields. Hillside soils would be considered less suitable for white grubs and would contribute to the conditions responsible for their low numbers.

Wireworm numbers remained about the same during late May through early July in all fields but increased about threefold in burned fields in the plains during July (Fig. 2). However, this mid-July increase was not significantly different from other treatments. Wireworm populations in fields on hillsides tended to be higher in slash-and-mulch than slash-and-burn.

Numbers of lesser cornstalk borer larvae increased from late May to early July and then disappeared abruptly in mid-July, when larvae were not collected from any sites (Fig. 3). Larval numbers tended to be higher on the hillsides than on the plains, but significant differences were not observed. Thin sandy soils with low water retention, typifies the soils on the hills and provides a favorable environment for lesser cornstalk borer larvae (2). Also, the borers are facultative saprophytes and feed on crop and non-crop plant residue (mulch), in conservation tillage fields (6, 7). Hillside fields in southern Honduras typifies no-till or conservation tillage production practices. The borers feed on mulch in the no-till system and crop damage may be less than that in conventional tillage fields where there is little or no mulch due to cultivation prior to planting. Cheshire *et al.* (6) and All *et al.* (2) indicated that lesser cornstalk borer larval infestations of corn were greatly reduced in

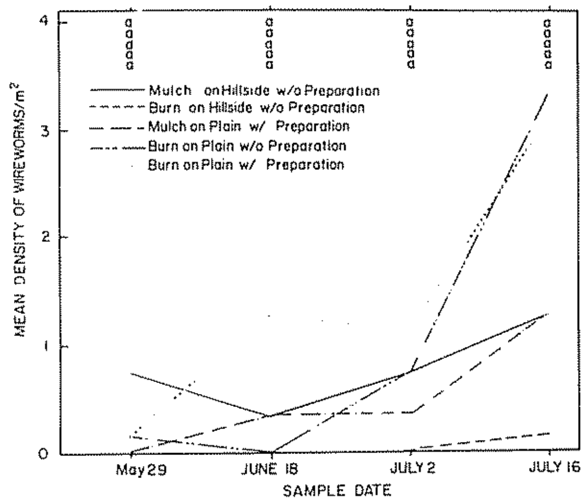

Fig. 2 Mean number of wireworms/m² in five different sorghum and maize intercropped systems in southern Honduras. 1985. Numbers on sample date with different letter (top of figure) in corresponding vertical position to treatment data are significantly different by Student-Newman Keuls' test (P ≤ 0.10)

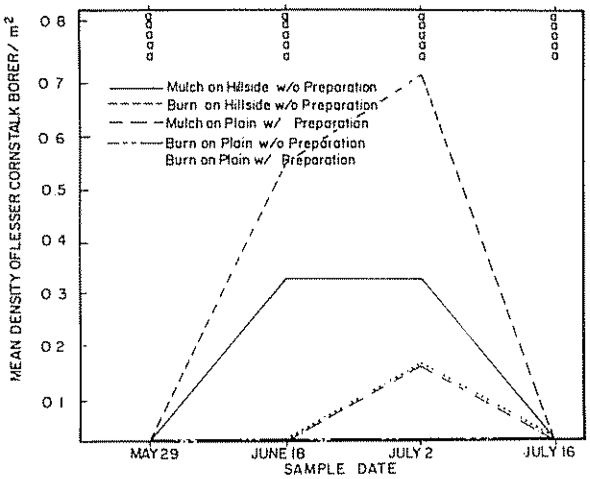

Fig. 3. Mean number of lesser cornstalk borers/m² in five different sorghum and maize intercropped systems in southern Honduras. 1985. Numbers on sample date with different letter (top of figure) in corresponding vertical position to treatment data are significantly different by Student-Newman Keul's test (P ≤ 0.10).

no-tillage compared to conventional tillage systems. This might be expected if the borers concentrated feeding on the mulch and not on the crop plants. If preplant vegetation, including mulch, becomes unacceptable to the borers soon after planting, the larvae move to and damage or destroy the seedling crop.

There were no specific trends in rootworm numbers in the different treatments (Fig. 4). However, numbers were somewhat higher in slash-and-burn fields without soil preparation on both the plains and hillsides. Turpin and Peters (36) reported that rootworm survival is related to soil moisture and texture. Although soil moisture data were not recorded soil moisture appeared to be lower on the hillside than the plains. The thin, shallow soils on the hillside dry quickly and adversely affected rootworm numbers. Moisture relationship studies with rootworms have been investigated by Marrone and Stinner (25, 26), Weiss and Mayo (38) and Lummus *et al.* (23). Turpin and Peters (36) reported that rootworm larvae prefer clay soils to sandy soils because clay soils hold moisture for a longer period of time. This is important when considering susceptibility of insects to dessication.

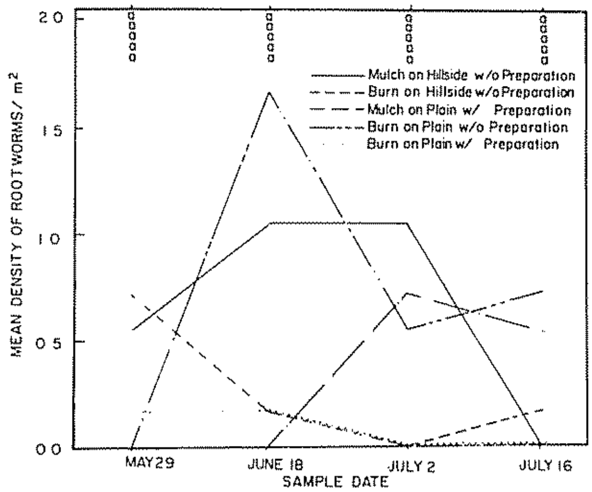

Fig. 4. Mean number of rootworms/m² in five different sorghum and maize intercropped systems in southern Honduras. 1985. Numbers on sample date with different letter (top of figure) in corresponding vertical position to treatment data are significantly different by Student-Newman Keuls' test (P ≤ 0.10).

Table 3. Seasonal mean population densities of selected soil-inhabiting phytophagous arthropods in intercropped sorghum and maize fields in three areas of southern Honduras, 1985.

	Mean[1] ± SEM number of arthropods[2] per 1 m² of soil				
Locations	Wireworms	White grubs	Rootworms	Lesser corn-stalk borer	Millipedes
Namasigue/ San Bernardo	1.50 ± 0.54 a[3]	2.93 ± 0.71 a	0.60 ± 0.29 a	0.11 ± 0.07 a	0.11 ± 0.07 b
Pavana	0.77 ± 0.20 a	5.00 ± 1.63 a	0.66 ± 0.16 a	0.05 ± 0.05 a	0.16 ± 0.08 ab
Alianza	0.33 ± 0.16 a	2.55 ± 0.72 a	0.22 ± 0.08 a	0.27 ± 0.14 a	0.27 ± 0.09 a

1 Mean of samples (n = 200) on four dates from May to July 1985.
2 Insects as immatures.
3 Means in a column not followed by the same letter are significantly different by Student-Newman-Keuls' test (P ≤ 0.10).

Table 4. Seasonal mean population densities of soil-inhabiting phytophagous arthropods in intercropped sorghum and maize fields in southern Honduras. 1985.

System[2]	Mean[1] ± SEM number of arthropods per 1 m² of soil				
	Wireworms	White grubs	Rootworms	Lesser corn-stalk borer	Millipedes
Hillsides					
Slash-mulch no soil prep	0.92 ± 0.28 a[3]	1.29 ± 0.30 c	0.64 ± 0.26 a	0.18 ± 0.18 a	0.83 ± 0.23 a
Slash-burn no soil prep	0.09 ± 0.09 a	1.01 ± 0.30 c	0.45 ± 0.09 a	0.36 ± 0.18 a	0.46 ± 0.17 a
Plains					
Slash-mulch soil prep	0.55 ± 0.14 a	4.62 ± 0.72 b	0.27 ± 0.18 a	0.09 ± 0.09 a	0.73 ± 0.27 a
Slash-mulch no soil prep	1.20 ± 0.26 a	8.42 ± 1.86 a	0.92 ± 0.44 a	0.00 ± 0.00 a	1.20 ± 0.26 a
Slash-burn soil prep	1.57 ± 1.03 a	2.03 ± 0.52 c	0.18 ± 0.11 a	0.09 ± 0.09 a	0.46 ± 0.41 a

1 Mean of samples (n = 120) on four dates from May 29 to July 23, 1985.
2 All fields slashed (stalks cut); mulch remained on ground if field not burned. Fields on hillsides without soil preparation prior to planting; fields on plains with soil preparation, except where indicated in 1985.
3 Means in a column followed by the same letter are not significantly different by Student-Newman-Keuls' test ($P \leq 0.10$).

Observations in 1985 revealed that millipedes can be serious pests on surghum and maize. Millipede population densities were about the same in hillside and plain fields regardless of burning or land preparation (Table 4). Rice (33), Heyward and Tissot (13), and Pearse (30), however, reported that numbers of centipedes and millipedes can be reduced by burning, often by as much as 80%.

1986 Study

As in 1985, a wide variety of soil arthropods were obtained from soil samples taken from production fields on the hillside and plain areas of La Coyota and El Conchal, respectively (Tables 1 and 2). With improved sampling and preservation techniques, a larger number of insect species were collected and identified than in the previous year.

Population densities of selected groups of arthropods were similar in intercropped sorghum and maize fields and fields of pure stand maize. Thus, data for both systems were combined for treatment analysis. Treatments are slash-and-burn, and slash-and-mulch fields in the hillsides and plains. Arthropods selected for comparisons of treatment effects on infestations were the groups that were most abundant, namely white grubs, wireworms, rootworms and millipedes.

The test design during 1986 allowed for direct comparisons of densities of selected arthropod groups in soils in fields on the hillsides and the plains. No significant interactions between site and cultural practice were observed for white grubs, wireworms or rootworms; therefore, the main treatment effects are discussed separately for each of these groups. The significant interaction between the main effects in relation to millipede numbers preclude similar discussions for this group.

Numbers of white grubs and wireworms were not significantly different in hillside or plains habitat sites; whereas, rootworms were collected in lower numbers from the hillsides than the plains (Table 5). White grub numbers in treatments were significantly different on three of eight sample dates (Fig. 5). On June 2 the slash-and-burn fields on the hillsides had significantly higher numbers of white grubs than the

Table 5. Seasonal mean population densities of selected soil-inhabiting phytophagous arthropods in intercropped sorghum and maize fields on hillsides and on the plains in southern Honduras. 1986.

Site	Mean[1] ± SEM number of insects per 1 m² of soil		
	White grubs	Wireworms	Rootworms
Plains	3.45 ± 0.82 a[2]	7.54 ± 3.00 a	2.66 ± 0.67 a
Hillsides	6.10 ± 1.58 a	4.90 ± 0.93 a	0.80 ± 0.32 b

1 Mean of samples (n = 480) on eight dates from May 20 to August 20, 1986.
2 Means in a column not followed by the same letter are significantly different by Student-Newman-Keuls' test ($P \leq 0.10$).

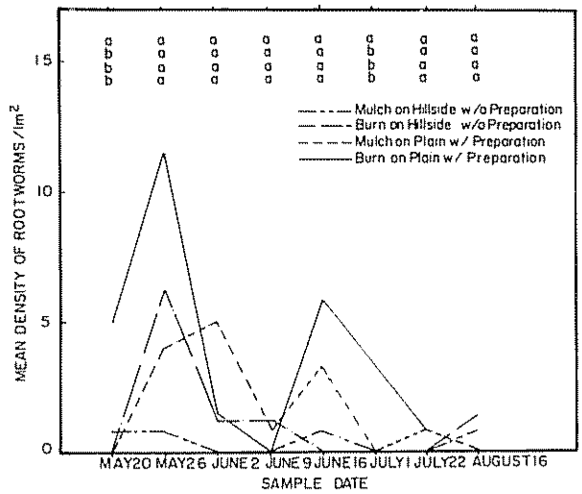

Fig. 5 Mean number of white grubs/m² in four different sorghum and maize intercropped systems in southern Honduras. 1986. Numbers on sample date with different letter (top of figure) in corresponding vertical position to treatment data are significantly different by Student-Newman Keuls' test ($P \leq 0.10$).

other treatments. Significant differences were observed also on June 9 when densities were higher in the slash-and-burn and slash-and-mulch fields on the hillsides and slash-and-mulch fields on the plains than the slash-and-burn fields on the plains. On July 22 the numbers in slash-and-mulch fields on the plains were higher than in the other treatments. The peak number of grubs was coincident with the onset of spring rains that occurred two weeks earlier on the hillsides than plains.

Early planting in uncultivated hillside fields did not hinder white grub establishment, whereas land preparation on the plains may have been responsible, in part, for destruction of some white grubs in these fields, as discussed previously. Burning the fields prior to planting reduced white grub numbers in the plains. The low numbers during late June to mid-August may be attributed to some extent to emer-

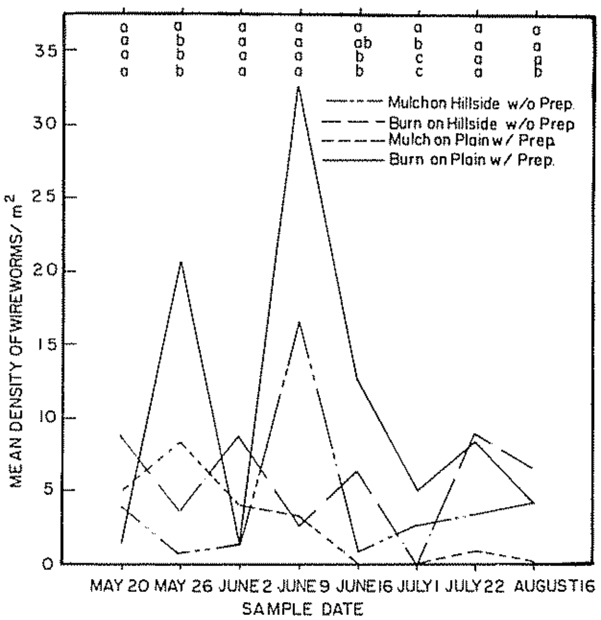

Fig. 6 Mean number of wireworms/m² in four different sorghum and maize intercropped systems in southern Honduras. 1986. Numbers on sample date with different letter (top of figure) in corresponding vertical position to treatment data are significantly different by Student-Newman Keul's test ($P \leq 0.10$)

Table 6.. Mean soil moisture on different dates in intercropped sorghum and maize fields in southern Honduras. 1986.

System[1]	Percent soil moisture on dates						
	May 20	May 26	June 2	June 9	June 16	July 1	July 22
Hillsides							
Slash-mulch no soil prep	18 5 b[2]	14 3 a	18 7 a	18 6 a	15 6 a	12 1 b	5.7 c
Slash-burn no soil prep.	16 7 b	14 8 a	16 5 ab	18 2 a	14 4 a	10 7 b	5 6 c
Plains							
Slash-mulch soil prep	23 8 a	24 2 a	28 1 b	22 6 a	16.9 a	17 7 a	8 8 b
Slash-burn soil prep	25 4 a	24 4 a	23 9 b	20.2 a	15.6 a	18 7 a	11 0 a

1 All fields slashed (stalk cut); mulch remained on ground if field not burned. Fields on hillsides without soil preparation prior to planting; fields on plains with soil preparation.
2 Means in a column followed by the same letter are not significantly different by Student-Neuman-Keuls' test ($P \leq 0.05$).

gence of adults and the drought period in mid-June to late July when soil moisture was reduced drastically (Table 6). During this time the number of grubs collected was low. The low numbers collected at this time may be related to the behavior of the grubs in response to unfavorable soil conditions. Grubs that move to a deeper location in the soil to escape the stress associated with drought may not be collected, thus these observations may not reflect a decline in population. However, the low soil moisture level of hillside soils could have contributed to conditions responsible for low population levels as reported by Jarvis (15) and Potter (32). The relationships of soil texture and moisture with insect survival and pest establishment were discussed above.

No consistent trends were observed for wireworm numbers on the hillsides or plains during the season (Fig. 6); but wireworm numbers were observed to be significantly higher in the slash-and-burn fields on the plains than the other treatments during May 26 and July 1. Also, significant differences were found on June 16 when wireworm numbers in slash-and-burn fields on the plains were higher than in slash-and-mulch fields on the plains and hillsides and on August 16 when wireworm numbers were significantly lower in slash-and-mulch fields on the plains.

Wireworms and rootworms were collected in significantly higher numbers in burned than in unburned fields (Table 7). Rootworm numbers were higher in slash-and-burn fields on the plains than in the other systems on two of eight sample dates only. The trend for higher numbers of rootworms and wireworms in burned fields than in unburned fields on the plains

Table 7. Seasonal mean effects of burning on selected insects in the soil in intercropped sorghum and maize fields on hillsides and on the plains in southern Honduras. 1986.

	Mean[1] ± SEM number of insects per 1 m^2 of soil		
System[2]	White grubs	Wireworms	Rootworms
Burn	4.65 ± 1.88 a[3]	9.70 ± 3.07 a	2.70 ± 0.66 a
No burn	4.66 ± 0.77 a	3.54 ± 0.85 b	1.08 ± 0.55 b

1 Mean of samples (n = 480) on eight dates from May 20 to August 20, 1986.
2 All fields slashed (stalks cut); mulch remained on ground if field not burned. Fields on hillsides without soil preparation prior to planting; fields on plains with soil preparation.
3 Means in a column not followed by the same letter are significantly different by Student-Newman-Keuls' test ($P \leq 0.10$).

indicates that burning may have an influence on rootworms. Cancelado and Yonke (5) reported that burning is one of the most important practices in prairie management. They listed fire as an "insecticide method" and reported that "fire is of course an effective means of destroying insects where its application is possible." Several authors including Rice (33), Komarek (20), Nagel (28), and Cancelado and Yonke (5) have indicated that infestations of some species of insects may be affected more by fire than others. During this study, farmers in southern Honduras started burning their fields as early as March 20 to April 20 and planted their seeds sometime between June 1 and June 11 (late planting due to delay in rains) thus providing enough time for insects like wireworms and rootworms to colonize non-crop vegetation in burned fields by mid to late May, as regrowth vegetation is generally abundant in burned fields (1, 22). This new plant material is attractive to some insects; thus, the regrowth plant material in burned fields may influence numbers of certain insects by attracting them from older vegetation in areas around the burned fields. Adults not killed by burning migrate to places offering more shelter and return later to the burned area to attack the regrowth vegetation (33). These insects lay eggs and are responsible for the infestations of soil pests that occur on the crops during the current, as well as the next growing seasons.

Komarek (19) and Hurst (14) reported that grass regrowth was abundant and plant quality, especially protein, calcium, phosphorous, potash and other elements, was increased following a burn. Thus, it is reasonable to attribute the increase in phytophagous insects in burned areas to an increase in nutritious and palatable food supply.

Millipedes were in significantly higher numbers in burned fields on the plains than in un-burned fields on the plains and fields on hillsides with and without burn. No significant differences in millipede numbers were observed between fields on the plains without burn and fields on hillsides with and without burn.

Millipedes have been identified as a pest of sorghum and maize seeds in southern Honduras (35). These pests are usually found in soils with high moisture. Sequeira (35) reported that farmers recognized millipedes as pests in gardens and on field crops, and considered them to be important to agriculture and medicine.

Burning does not appear to be an effective practice for control of soil-inhabiting, phytophagous arthropod pests in intercropped sorghum and maize in southern

Honduras. Higher numbers of some arthropods (e.g. wireworms, rootworms and millipedes) were collected in burned fields. This observation appeared to be related to arthropod establishment in regrowth vegetation in burned areas.

In addition to the observed negative effects of burning as a control for soil-inhabiting arthropod pests on sorghum and maize, as reported herein, there are additional obvious negative effects that can be associated with this agricultural practice in Honduras and surrounding countries. These include reduced soil fertility, increased erosion on sloped fields, public health hazards associated with air pollution, air traffic delays due to smoke, increased atmospheric heat caused by the greenhouse effect of the smoke, and the reduction of soil moisture due to removal of ground cover and resultant water run-off and evaporation.

CONCLUSIONS

Soil inhabiting arthropods most common in intercropped sorghum and maize fields in southern Honduras in 1985 and 1986 were white grubs, wireworms, rootworms, lesser cornstalk borer, and millipedes. Densities of the insects in three sampled areas were similar indicating that these pest groups are widely distributed throughout the south. Numbers collected in soil samples taken between the rows or on the hills were not different. However, a trend was observed in soil samples for more insects to be associated with crop plants than with other plants or areas without vegetation.

Generally, white grubs, wireworms, rootworms, lesser cornstalk borers and millipedes were found in higher numbers on the plains than on hillsides. Soil texture was more suitable for soil moisture retention on the plains and this condition apparently contributed to arthropod establishment and density increase in fields on the plains. Although densities of soil arthropods appeared to be low, many of the fields studied reached the economic threshold reported by Andrews (4) and King and Saunders (18). Thus, these arthropods are a major constraint to sorghum production; and, if not controlled, replanting is necessary at additional cost to the farmer.

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Manejo del Suelo, Rastrojo y Plagas: Interacciones y Efecto sobre el Maíz[1]

M Carballo, J L Saunders***

ABSTRACT

The effects of different forms of soil preparation, crop residue management and insect control on insect pest incidence and damage were studied during two maize cropping cycles. Maize yield was significantly reduced in plowed plots with no insecticidal soil pest control. Yields in no-till systems were less sensitive to insecticide application due to less damage by pests. Yield reduction in plowed plots was correlated to plant population loss due to *Cyrtomenus bergi* Froeschner attack. The no-till system was associated with larger white grub (*Phyllophaga* spp.) populations. Incidence and damage by the foliar pests (*Diabrotica balteata* Le Conte and *Spodoptera frugiperda* J.E. Smith) was less in systems with crop residues on the soil.

COMPENDIO

Se estudió el efecto de diferentes formas de preparación del suelo, del manejo de residuos y del combate de plagas sobre la incidencia y daño de insectos en dos ciclos de cultivo de maíz. El rendimiento de maíz obtenido en los sistemas con suelo arado se redujo significativamente cuando no se combatieron las plagas del suelo. El rendimiento en cero labranza fue menos sensible a la aplicación de insecticidas ya que el daño de plagas fue menor. Esta reducción del rendimiento en los sistemas con suelo arado estuvo asociado con la pérdida de plantas provocada por *Cyrtomenus bergi* Froeschner. La cero labranza fue desfavorable a este insecto. La pérdida de plantas en cero labranza estuvo asociada con la mayor población de larvas de gallina ciega (*Phyllophaga* sp.) en el suelo. La incidencia y daño de plagas del follaje como adultos de *Diabrotica balteata* Le Conte y gusano cogollero (*Spodoptera frugiperda* J.E. Smith) se redujo cuando los residuos de cosecha permanecieron sobre el suelo.

INTRODUCCION

La regulación cultural de plagas mediante algunas prácticas de manejo de rastrojo de cosechas y tipos de labranza ha demostrado ser tan efectiva como el combate con insecticidas La cero labranza con presencia de un mantillo de rastrojo sobre el suelo reduce el daño de algunas plagas a los cultivos con respecto a la labranza convencional, por ejemplo *Diabrotica virgifera* Le Conte y *D barberi* Smith y Lawrence (7, 10), *Elasmopalpus lignosellus* Zeller (1), *Delia platura* Meigen (8), *Epilachna varivestis* Mulsant (17), *Amrasca biguttula* y *Ophiomyia phaseoli* Tyron (16) y *Spodoptera frugiperda* J.R. Smith (4, 9).

Sin embargo, las prácticas de remoción del suelo y eliminación o incorporación de rastrojo mediante el arado en labranza convencional controla a otras plagas, disminuyendo su daño al cultivo. Esto ocurre para *Agrotis ipsilon* Hufnagel (11), *Melanophus femurrubrum* De Geer (17), *Pseudaletia unipuncta* Haworth (12), *Phyllophaga anxia* Le Conte (15) y *Phyllophaga* sp. (13).

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