A complex of lepidopterous defoliators on sorghum and maize in Honduras: some management tactics[1]

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Abstract. The USAID sorghum/millet (INTSORMIL) collaborative research support program (CRSP) involving Mississippi State University (USA), Zamorano and SRN (Honduras), has investigated insect constraints to sorghum and maize production on low-income farms in Honduras during the past 15 years. This paper summarizes some of the accomplishments of this program. A complex of lepidopterous larvae (family Noctuidae) referred to as "langosta" by subsistence farmers in southern Honduras was identified to consist of *Spodoptera frugiperda*, *S. latifascia*, *Metaponpneumata rogenhoferi* and *Mocis latipes*. The defoliators destroy or reduce plant stands requiring replanting by the resource-poor farmers; this may be prohibitive. Pest biology and dynamics, and information on relationships with crop and noncrop vegetation were obtained for use in developing applicable, implementable, cost effective, and sustainable insect management practices. On-farm studies were done to assess the success of management strategies. These strategies included planting date, crop rotation, residue destruction, planting systems, host plant resistance, weed management, and biological and chemical control. Systems developed for recommendation included two low-cost cultural practices, namely delayed planting and weed management utilizing family labor. Delayed planting (5-10 days after weed emergence) and weed control after crop emergence (10-14 days) resulted in less crop damage by the langosta. Improved sorghum cultivars and early maturing maize hybrids are recommended to escape or tolerate insect damage. A single insecticide application has been recommended with a 40% infestation. Sorghum production was increased 20% and maize 35% using these management practices. Increased yields of both crops would improve farm income, and should improve diet and nutrition of farm families.
Key words: Insect pests of sorghum and maize, integrated pest management.

Resumen: El Programa de apoyo colaborativo a la investigación (CRSP) y la USAID, sorghum/millet (INTSORMIL) en los cuales participan la Mississippi State University (USA), Zamorano y la Secretaría de Recursos Naturales de Honduras, ha investigado los problemas causados por insectos a la producción de sorgo y maíz en fincas de pequeños productores en Honduras, durante los últimos 15 años. Esta publicación sumariza algunos de los logros alcanzados por este programa. Un complejo de larvas de lepidópteros (Familia Noctuidae) conocido como "langostas" por los productores de la zona sur de Honduras, fue identificado como *Spodoptera frugiperda*, *S. latifacia*, *Metaponpneumata rogenhoferi* y *Mocis latipes*. Estos defoliadores destruyen o reducen el número de plantas y se requiere resiembra, que para los productores de escasos recursos puede ser prohibitiva. Información de biología y dinámica de plagas, e interrelaciones con cultivos y malezas fue obtenida para desarrollar prácticas de manejo sostenible de insectos que sean aplicables, implementables y de bajo costo. Se hicieron estudios en fincas para identificar estrategias exitosas de manejo. Estas estrategias incluyen fechas de siembra, rotación de cultivos, destrucción de residuos, sistemas de siembra, manejo de malezas, resistencia de plantas hospederas, y controles biológicos y químicos. Los sistemas desarrollados para recomendación incluye dos prácticas culturales de bajo costos: siembra tardía y manejo de malezas con mano de obra familiar. La siembra tardía (5-10 días después de emergencia de malezas) y control de malezas después de la emergencia del cultivo (10-14 días) resultó en menos daño al cultivo por la langosta. Los cultivares de sorgo mejorado y maíz hibrido de maduración temprana son recomendados para tolerar o escapar del daño de insectos. Una sola aplicación de insecticida ha sido recomendada si hay un 40% de infestación. La producción de sorgo fue aumentada en 20% y la de maíz en 35% usando las recomendaciones de prácticas de manejo. El aumento en rendimientos en ambos cultivos podría mejorar el ingreso, nutrición y dieta de las familias campesinas.
Palabras claves: Plagas insectiles de sorgo y maíz, manejo integrado de plagas.

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INTRODUCTION

Sorghum and maize are intercropped in many areas of Central America as a risk aversion practice, because farmers can substitute sorghum for maize to feed their animals and family if the maize crop is lost to drought (DeWalt and DeWalt, 1987). The native landrace sorghums, regionally called "maicillo criollo", are sensitive to photoperiod and are planted in late April and May after the start of the rainy season. They generally do not differentiate and begin rapid growth and internode elongation until October. This is after maize has reached maturity and has been harvested in August-September. The "maicillo criollo" is harvested in December and January (Meckenstock, 1988, Rosenow, 1988).

A complex of lepidopterous insect larvae attack the sorghum and maize crops during the "primera" (first, April-July) and to some extent the "postrera" (second, August-December) growing seasons. The farmers in southern Honduras do not always distinguish between the species of larvae that attack the crops and tend to group them as one. This group of lepidopterous larvae is referred to as the "langosta", a term that is used to describe the extensive feeding damage associated with large locust populations (Portillo *et al.*, 1991).

The "langosta" cause extensive leaf feeding damage and may destroy or reduce plant stands of the sorghum and maize crops, thus requiring replanting (Portillo *et al.*, 1994a). The cost of additional seed and hand labor for replanting is considerable and possibly prohibitive for the subsistence farmer. Replanting results in delay of crop maturity, thus the plants are often exposed to increasingly large numbers of insect pests as the crop develops during the growing season. The crop may mature during the "canícula" (drought period of varing duration between the primera and the postrera) further reducing yields.

STUDY AREA AND CROP PRODUCTION SYSTEM

The lepidopterous insects ("langosta") infesting sorghum and maize were investigated in areas located in the Department of Valle in southern Honduras, one at El Conchal on the Pacific coastal plain (*ca.* sea level) near the border of El Salvador, and the other, La Coyota, located nearby in the foothills at 52 m above sea level (Figure 1). The two areas are separated by less than 10 km with coordinates *ca.* 13° 31' N, 87° 43' W. Approximately 82% of the sorghum acreage in these locations is intercropped with maize (Lopez, 1990).

Figure 1. Map of the research location in Southern Honduras.

Fields on the coastal plains (average size of 2.4 ha) experience a higher crop production technology level because the land is more suitable for agricultural practices. Land is prepared with tractors or ox-pulled plows, some fertilizers are used and insecticides may be applied at planting and/or on foliage. In the foothills, fields with an average size of 1.5 ha have steep slopes and rocky soils, tractors are not used for crop production, manual weed control practices are used, and the use of fertilizer and insecticide is limited. "Maicillo criollo" sorghum and maize are intercropped by the subsistence farmers at both locations. Slash and burn are common pre-plant practices for this region, as they are in other locations in Central America.

THE LANGOSTA COMPLEX

Plants were examined for larvae using destructive whole plant sampling techniques. The samples were taken periodically throughout the first growing season to identify the pest insects and record infestation levels. The identity and absolute numbers of larvae were recorded. Since the two locations used for observation are relatively near (less than 10 km apart), the data on occurrence of the larvae in the two areas were combined for analysis and discussion.

The extensive defoliation damage to the sorghum and maize crops in southern Honduras during 1985-1995 was caused principally by several species of lepidopterous larvae (family Noctuidae), and included *Spodoptera frugiperda* (J.E. Smith) the fall armyworm, *S. latifascia* (Walker) the black armyworm, and *Metaponpneumata rogenhoferi* (Moschler), as well as *Mocis latipes* (Guenee), a grass looper (Pitre, 1988, Portillo *et al.*, 1991). The spring rains triggered the onset of larval activity on noncrop vegetation and sorghum and maize. *S. frugiperda* was the most abundant of the langosta species in the area, *S. latifascia* and *M. rogenhoferi* were particularly damaging to the crops early in the season, whereas *M. latipes* occasionally caused damage in mid-season.

RELATIONSHIP WITH NONCROP VEGETATION

The "langosta" species were observed to have a close relationship with noncrop vegetation present in infested fields. Weed populations influenced densities of *S. frugiperda* and *M. latipes*. When weed infestation was high, the *S. frugiperda* population was lower on sorghum and maize than when weed infestation was low, but the *M. latipes* population on the crops was higher when weed infestation was high (Portillo *et al.*, 1991).

S. frugiperda larvae occurred on noncrop vegetation in irrigated areas throughout the dry periods and before the rainy season began. Moths and larvae were observed to be active in areas where some irrigation water, applied earlier, allowed the noncrop vegetation to remain attractive to the armyworms. *S. frugiperda* is active throughout the year in Honduras, suggesting that this species does not become inactive or diapause during the dry season (summer, December into April) in Honduras.

M. rogenhoferi and *S. latifascia* appeared on the crops in early May to mid-June. These two species were abundant during early season, representing as high as 60% and 13%, respectively, of the larval complex on sorghum and maize in some years in the hills (Table 1) (Portillo *et al.*, 1991). They infested noncrop vegetation adjacent to and, to some degree, within crop fields as feeding hosts prior to crop planting and emergence. This noncrop vegetation provided the earliest available host plants for the "langosta". These Lepidoptera initiated infestations in areas where the rains occurred first. However, larvae were more abundant and were observed to occur first in the hills (Portillo *et al.*, 1991).

M. rogenhoferi larvae reared in the laboratory on different crop and noncrop species developed to pupae, but many did not emerge as adults until several months later. It appears that this species can enter diapause, becoming inactive in the pupal stage in the soil during the long dry season. This species appeared to have one and possibly two generations per year (Portillo, 1994). Diapause in *S. latifascia* was not investigated. This species appears to have several generations per year, but only one damaging generation on sorghum and maize. The source habitat for *S. latifascia* and *M. rogenhoferi* may exist in the foothills or farther inland. A source habitat is an area where environmental factors are sufficient to allow a species to carry out its life history (Pulliam, 1988).

Table 1. Percent of the species composition of the "langosta" complex on sorghum and maize throughout the growing season in southern Honduras, 1988-1989.

Species	Early	Middle	Late
Metaponpneumata rogenhoferi	60	0	0
Spodoptera frugiperda	25	95	97
Spodoptera latifascia	13	5	3
Mocis latipes	2	0	0

Laboratory feeding studies with *M. rogenhoferi* and *S. latifascia* indicated that sorghum and maize were not suitable for the larvae to complete a life cycle compared with some noncrop vegetation (Portillo, 1994). Sorghum and maize may be considered sink habitats, that is, areas where factors are not sufficient to experience population growth (Pulliam, 1988). It is possible that these two species feed on sorghum and maize as an alternate host that is readily available, but may be required to feed on other types of vegetation to complete their life cycle.

The grass looper *M. latipes* was observed to feed in large numbers on weed grasses during the early insect developmental stages. As the larvae developed and their extensive feeding exhausted the preferred food sources, the later instars moved to surrounding sorghum and maize. Thus, higher populations of *M. latipes* were observed on the crops (similar infestations on both crops) in areas with highest density of the weed grasses (Portillo *et al.*, 1991). Certain weed grass species have been shown to be preferred for oviposition by this grass looper (Dean, 1985, Dean *et al.*, 1985). This would explain the somewhat lower infestations of *M. latipes* on sorghum and maize in areas with low weed infestation.

Following harvest of the "maicillo criollo" until it rains sometime in April or May, there are no sorghum or maize plants for the "langosta". This does not preclude the use of native grasses by the "langosta" larvae to survive this period when the crop plants are not available. Soon after the rains begin and the noncrop weed species emerge, the "langosta" infests this vegetation. When the crops become established and the noncrop vegetation is scarce (relative to the larger areas planted to the crops) or devoured, the "langosta" larvae move to surrounding marginal habitats, like sorghum and maize. However, broadleaf, noncrop plants appear to be better hosts than sorghum or maize for several species in the "langosta". As observed with *S. frugiperda*, as populations of these lepidopterous pests were distributed over the noncrop vegetation in crop fields during the early season, lower infestations of these pests were encountered on the crops (Portillo *et al.*, 1991).

***Spodoptera frugiperda*.** This armyworm was present on sorghum and maize throughout the growing season. It showed a preference for maize over sorghum, with approximately 70% of the larvae infesting maize. The larvae feed mostly in the whorl of the crop plants during the early stages of plant growth. The most prevalent weed grass, *Ixophorus unisetus* (Presl.) Schlecht (Poaceae) on the coastal plains in southern Honduras, and several broadleaf weeds, were as suitable as sorghum and maize as larval feeding hosts for *S. frugiperda* (Portillo, 1994).

***Metaponpneumata rogenhoferi*.** This lepidopterous pest was most damaging during the early part of the "primera", and was not found on sorghum or maize at other times (Portillo *et al.*, 1991). The larvae feed on the outer parts of the crop plants and do not move into the whorl, as does *S. frugiperda*. This species did not develop as well on sorghum or maize as on several common broadleaf weed species found in southern Honduras (Portillo, 1994).

***Spodoptera latifascia*.** This armyworm, occurring rather sporadically, preferred noncrop vegetation over the grain crops, as did *M. rogenhoferi*, and the feeding behavior and development on the crop plants were similar for the two insects species (Portillo, 1994). Fewer larvae occurred on sorghum and maize in areas with weeds than in areas with weed control, as the insects preferred to infest the noncrop vegetation (Portillo *et al.*, 1991). However, larvae of this species were commonly observed to build up to large numbers on sorghum and maize in fields where the preferred noncrop vegetation was not available, causing considerable damage to the crops.

In comparisons of "langosta" oviposition and larval development on sorghum, maize and noncrop plants, *S. latifascia* preferred maize, *Amaranthus* (probably *A. hybridus* L. or *A. viridis* L.) (Amaranthaceae), and *Ixophorus unisetus* for oviposition (Portillo *et al.*, 1996a). *Ipomoea* sp. (probably *I. purpurea* (L.) Jacq. (Convolvulaceae), *Melampodium divaricatum* (Rich ex Pers.) DC. (Asteraceae), and *Portulaca oleracea* L. (Portulacaceae) were only suitable hosts for oviposition. *I. unisetus* was a poor host for *S. latifascia* and *M. rogenhoferi* larval development, but was a good host for *S. frugiperda*. Host preferences (eg., host selection, feeding and development of immatures to adulthood) are important traits that define the ability of phytophagous insects to efficiently utilize a particular plant. This is important when considering the role of noncrop plants as hosts for the "langosta" complex and the potential movement of the insects to crop plants during the growing season.

***Mocis latipes*.** This grass looper was most common in sorghum and maize crops during mid- season. The two crops were equally infested. The looper represented 70% of the insect complex on the two crops late in the first growing season in one year, but usually contributed no more than 15% at this time in other years (Portillo *et al.*, 1991).

LANGOSTA MANAGEMENT PRACTICES

Crop Rotation and Residue Destruction. Lower infestations of *S. frugiperda* larvae were found on early whorl stage sorghum and maize in unburned fields than in burned fields in southern Honduras. This species is known to fly over long distances (Sparks, 1979), and may invade the crop fields from surrounding areas (Pitre, 1988, Portillo *et al*,. 1991). These observations indicate that crop rotation and crop residue destruction by burning may be of little value for control of *S. frugiperda* (and possible other species in the "langosta" complex) infestations in intercropped sorghum and maize.

Planting Date. Farmers in southern Honduras have historically planted sorghum and maize as soon as they were able to get into the fields after the onset of the rainy season. The rains appear to stimulate the termination of diapause in pupae and initiate insect activity, the rains also stimulate germination of weed seeds. The sorghum and maize crops planted at different times after the initial rains compete with the weeds for moisture, but also are exposed in their early stages to insect pests. The "langosta" larvae have been observed to be more abundant on and damaging to sorghum and maize when the crops were planted at certain times after the initial rains, but less damaging to the crops planted at other times. Date-of-planting investigations in the study area indicated that the crops planted 5-10 days after weed emergence were damaged less by "langosta" larvae than crops planted earlier.

Management of Noncrop Vegetation. Weed control would be expected to benefit crops by reducing plant competition thus increasing crop yield. However, three of the four species in the "langosta" complex were observed at higher levels on maize and sorghum plants in fields without weeds than in fields with weeds (Figures 2 and 3) (Portillo *et al.*, 1991), which suggests that removing weeds from crop fields at or immediately prior to planting results in larger "langosta" infestations on, and greater damage to the crops and reduced crop yields.

Monitoring source habitats for occurrence of the "langosta" larvae and defining planting dates to escape "langosta" damage are low cost control measures that could be employed by subsistence farmers. Weed removal in the relatively small source habitats in crop fields 10-14 days after crop emergence could result in reduced infestations on the early stages of the crops. The "langosta" infestation in crop fields remains primarily on the preferred noncrop vegetation for feeding during the early growth stages of the crops (Portillo *et al.*, 1996b) and although a small proportion of the pest may attack sorghum and maize, damage to the crops is minimized. These tactics are within the means of the resource poor farmers since they primarily involve investment of their own labor. Insecticide could be used to control the "langosta" larvae on the noncrop vegetation serving as habitats, but it is doubtful that subsistence farmers will invest in spraying insecticides on weeds. Information on specific weed density level and planting date relationships with "langosta" species diversity and density and crop damage and yield can be useful in developing cropping systems and implementation of insect control measures which would include practical "langosta" management practices for subsistence farmers.

Planting System. More maize plants than sorghum plants were infested with *S. frugiperda* in "surco alterno" (plants in alternate rows) and "casado" (plants in same hill) systems, but not in the "golpe alterno" (plants in alternate hills) system where infestations on the two crops were about equal. Sorghum in the "casado" system with a moderate weed infestation had a lower *S. frugiperda* infestation than sorghum planted with a maize trap crop (10% of area planted to maize, a preferred host for *S. frugiperda*) or in pure stand sorghum (Castro *et al.*, 1989). The lower *S. frugiperda* infestations on sorghum and maize in the "casado" system may be associated with host preference by the moths for the weed grasses (Portillo *et al.*, 1996a), but this may be related to other factors associated with the egg laying behavior of the moths. It has been demonstrated that an insect's host finding ability can be altered by the proximity of another plant species (Tahvanainen and Root, 1972). This may result in less attraction of ovipositing moths to suitable host plants in the general area compared to crops in pure stands. Sorghum in "golpe alterno" may have a higher infestation than sorghum in "surco alterno" because the larvae on maize in adjacent hills disperse to the closely planted sorghum when larvae reach high densities on the preferred maize. A similar relationship may exist for the other closely related pest species in the "langosta" complex.

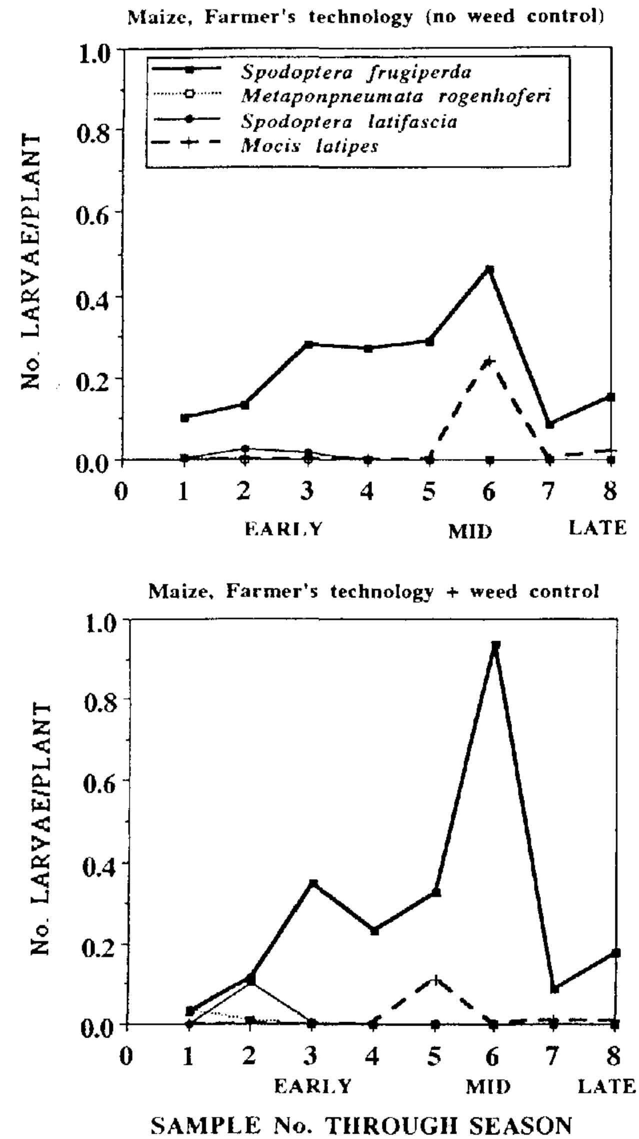

Figure 2. Population dynamics of the "langosta" complex in maize grown intercropped with sorghum under no weed control (top) and weed control (bottom) production practices in Southern Honduras, 1988.

Traditionally, the "casado" system of planting is practiced by subsistence farmers, even when yields are lower for both crops than when other spatial arrangements of crops are used. The "golpe alterno" system is often used in the rocky foothills, increasing the potential for higher-than-normal *S. frugiperda* infestations on sorghum. This system may enhance natural selection for host plant resistance to this pest. The "aporque" planting system, where sorghum is planted about three weeks after maize, was not included in this crop planting system investigation. This system is presently being investigated in relation to planting date and weed management effects on the "langosta" species.

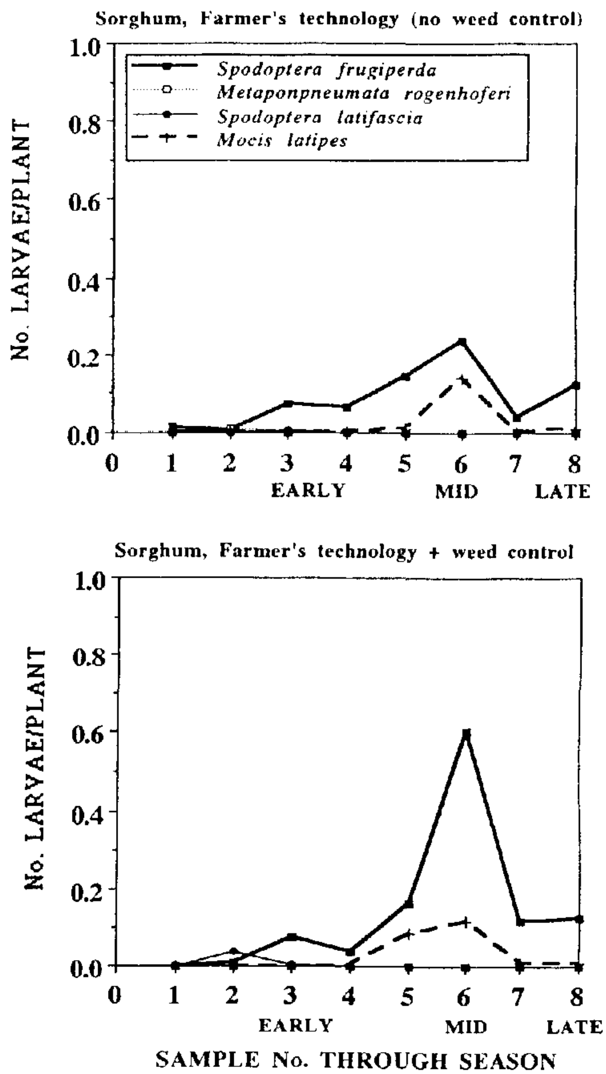

Figure 3. Population dynamics of the "langosta" complex in sorghum grown intercropped with maize under no weed control (top) and weed control (bottom) production practices in Southern Honduras, 1988.

Trap Crop. The use of maize as a trap crop in sorghum and maize intercropping systems, where the pest, (eg., *S. frugiperda*) infestation would be concentrated on the preferred maize, is ecologically practical (Castro *et al.*, 1988). This cropping practice could be used to monitor pest occurrence, as well as concentrating the pest infestation on the trap crop to allow measures to be applied for control of the pests over the small trap crop area. There is need to determine the spatial separation of the two crops to maximize the effects of oviposition preference for maize and minimize the influence of plant proximity and movement of the "langosta" species from one crop to the other.

Host Plant Resistance. The tropical landrace "maicillo criollo" is cultivated on about 70% of the sorghum area in Central America, with greatest concentrations in El Salvador and Honduras. These "maicillo criollo" generally have low yield potential which limits yield increase even when crop production conditions are favorable. Initial investigations suggested that antibiosis host plant resistance may be involved in declining *S. frugiperda* populations on the "maicillo criollo" sorghums (Meckenstock *et al.* 1991). Antibiosis is the adverse effect of the host plant on the biology of the insect and can involve decreased size, abnormal length of life, reduced fecundity, and increased mortality. These biological characteristics are used to make inferences about antibiosis resistance in plants. The antibiosis mechanism of resistance was evaluated in the laboratory and in the field measuring larval development and ability (fitness) of the population to sustain increased growth (Meckenstock *et al.*, 1991, Lopez *et al.*, 1996a).

Moderate levels of antibiosis resistance (higher mortality rates, lower pupal weights, suppressed population density increase) to *S. frugiperda* were observed in some of the "maicillo criollo". The antibiosis resistance appears to be widespread in the landrace populations. This resistance could be combined with other resistant genotypes to produce an enhanced level of antibiosis. The process of differential selection of cultivars with generic dissimilarities has resulted in the accumulation of antibiotic alleles which appear to confer a broad level of intermediate resistance to *S. frugiperda* through reduced fecundity. Low egg laying potential can be related to poor insect growth and development, as expressed in low pupal weight. Sorghums identified with moderate levels of antibiosis resistance are included in the list in Table 2.

The landrace San Bernardo III has been successfully combined with an elite source of resistance ('AF28', identified in Brazil to increase *S. frugiperda* larval mortality) to increase the level of resistance in this population (inbred line) (Lopez *et al.*, 1996b). Improved landrace sorghum cultivars have yield advantages as much as 31% over the *maicillo criollo* ancestors under the same subsistence crop production practices. Resistance to other species in the *langosta*, when identified and incorporated into conventional cultivars, should further improve yield potential of sorghums developed in the Honduran National Sorghum Breeding Program.

Table 2. Mean *Spodoptera frugiperda* female pupal weight (mg) recorded from laboratory feeding experiments. Low pupal weight can be related to low egg laying potential.

Food source	Weight (mg)
Artificial Diet [1]	237
Sorghum Cultivars:	
Gigante Pavana	208
Porvenir	202
DMV -198	202
DMV -143	200
Paquete	197
Hilate -179	191
Lerdo -104	187
Piña -61	184
San Bernardo III	174
dw MC -36	152
Angel de Limón	144
Corona -195	143
Variedad Blanca	136

[1] Contains necessary ingredients for optimum growth and development of *S. frugiperda*.

Biological Control. A nematode, *Hexamermis* sp. (Mermithidae), and the wasp *Chelonus insularis* (Cresson) (Braconidae) are the most frequently encountered parasitoids of *S. frugiperda* in Central America (Wheeler *et al.*, 1989). In several field studies parasitization (up to 71%) by the endoparasitic nematode increased as rainfall increased (Castro *et al.*, 1989). Rain-splashes transfer nematodes from the soil onto the plants. Larval mortality occurs principally in the fifth instar (59%), but also in the fourth instar (15%). *C. insularis* parasitized up to 69% of the *S. frugiperda* larvae in other field studies. In general, weed control did not appear to have an influence on the levels of fall armyworm larvae parasitized by either parasitoid throughout the growing season (Figure 4). However, fall armyworm larvae collected on maize 23 days after planting in plots treated with conventional practices (no weed control, 12% weed coverage) had a significantly greater percentage of parasitization by the hymenopterous parasite than larvae collected in plots with conventional practices plus weed control (3% weed coverage) (Portillo *et al.* unpublished data). The differences in weed cover within treatment plots may have been responsible for this observed increase in parasitization, however, this was not documented. In addition to the above parasitoids, a fly pupa (Diptera: Tachinidae) was recovered from larval collections of *S. latifascia* and *M. latipes*, whereas *M. latipes* was parasitized by a wasp (Hymenoptera: Braconidae, unidentified species). Only the nematode was recovered as a parasitoid of *M. rogenhoferi* larvae. Except for high mortality (40%) of *M. latipes* caused by the nematode in 1988-1989, parasitization levels on these three members of the langosta complex were lower (13-27%) than those observed for fall armyworm (Figures 4 and 5). Information is needed on the influence of natural control agents on the species in the "langosta" complex in order to determine their impact in sorghum-maize intercropping production systems on subsistence farms in different regions of Honduras.

Chemical Control. Generally the resource poor, low income farmers do not have money to purchase chemicals, thus they use conventional subsistence crop production practices. Farmers who can afford insecticides and have access to equipment spray their crops when infested with the "langosta". Because of the geographical and biological diversity of species in the "langosta" complex, controlling this group of Lepidoptera on intercropped sorghum and maize is a formidable challenge.

The need for insecticide control of the "langosta" on sorghum and maize depends upon pest infestation level and stage of development of the crops. Application of insecticide is often not practical or economical on small subsistence farms. The back-pack, compressed-air sprayer is often used by the farmer. The insecticide spray is directed into the whorl where certain "langosta" species larvae (eg., *S. frugiperda*) are feeding, thus plant height and canopy density limit effectiveness of insecticide spray application. Pest control may be inadequate due to insufficient coverage with the spray materials and multiple spray applications generally are required.

Granular insecticide applied at planting and seed treated with insecticide were shown to effectively protect the sorghum seed from soil arthropod pests (Trabanino *et al.*, 1987), with extended residual benefit up to 21 days after planting, by significantly reducing the number of plants infested with fall armyworm (Table 3) (Portillo *et al.* 1994b). The efficacy of these materials on *M. rogenhoferi* and *S. latifascia* needs further investigation as these two members of the "langosta" complex are most damaging during the first 2-3 weeks after crop emergence. Some subsistence farmers already are using granular insecticides by mixing the granules with the seed at planting time. Farmers need to be instructed about the safe handling of these materials, using gloves, as well as the appropriate application methods to avoid crop injury.

Insecticides have been recommended when 40% of the plants are infested with *S. frugiperda*. The insecticide is most effective using a high volume of water, and would be expected to be more effective against some of the "langosta" species (eg., *S. latifascia* and *M. rogenhoferi*) feeding on the outer leaves on the crop plants, compared to *S. frugiperda* feeding deep in the whorl of the plants. Inadequate timing of spray application is often observed on subsistence farms in southern Honduras. Farmers usually spray after considerable crop damage has occurred and larvae of the "langosta" complex have reached mid-to late instars greatly reducing the efficacy of the insecticides. The risk of insecticide intoxication by subsistence farmers is drastically increased by the use of highly toxic insecticides (e.g., methomyl) and the liberal exposure levels to these materials by walking through the crop fields without any protection equipment such as gloves, coveralls, and respirator. Granular or seed treatment insecticides would be a safer alternative.

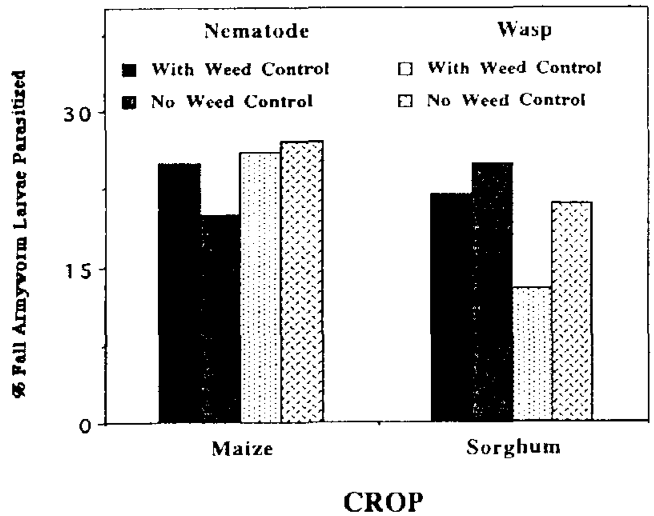

Figure 4. Parasitization of fall armyworm larvae collected from intercropped maize or sorghum grown under no weed control or with control production practices in Southern Honduras, 1990.

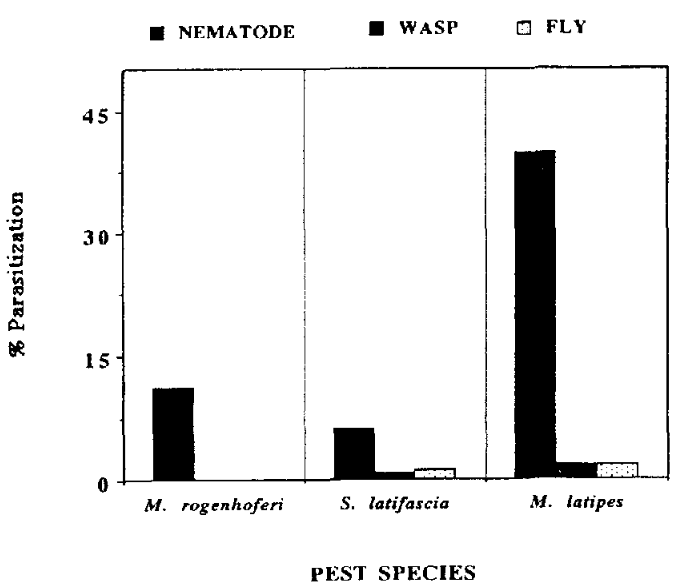

Figure 5. Parasitization of *Metaponpneumata rogenhoferi*, *Spodoptera latifascia*, and *Mocis latipes* larvae collected on intercropped sorghum and maize in Southern Honduras, 1988-1989.

Table 3. Efficacy of various seed treatment and granular insecticides applied on sorghum at planting for control of FAW (*Spodoptera frugiperda*) larvae 21 days after crop emergence, 1989.

Treatment	Rate[1]	Plants infested with FAW (%)
Furathiocarb 400 CS	25 ml/kg seed	9
Furathiocarb 400 CS	50 ml/kg seed	4
Furathiocarb 400 CS	75 ml/kg seed	8
Terbuphos 10 G	0.5 g/hill	6
Carbofuran 10 G	1.0 g/hill	8
Furathiocarb 10 G	0.5 g/hill	9
Kerosene	80 ml/kg seed	11
Control	-------	18

[1] Rate expressed as amount of formulated product per kg of seed for seed treatment, or per sorghum hill for at planting in-furrow treatments. Sorghum was planted in 0.8 m rows and hills were 0.25 m apart within the rows.

THE LANGOSTA CHALLENGE

The "langosta" pest complex exists in a mosaic of different micro-habitats. For example, *S. frugiperda* utilizes sorghum and maize as a host throughout the crop growing season, whereas the crops serve as a sink habitat for other armyworm species in the complex. The lepidopterous population decreases on the crops and survival and population increase depends on nearby noncrop source habitats.

This geographically and biologically diverse group of lepidopterous insects requires an array of integrated pest management practices. The manipulation of a habitat may have a positive influence on one species only to have an adverse effect on another species. Weed control reduced the population of *M. latipes*, but increased populations of armyworms on the crops. Whereas, weed management practices which allowed some noncrop vegetation to remain in the production field during the early stages of crop development contributed to lower insect damage to the sorghum and maize. Ecological studies with each of the "langosta" species are needed to elucidate the significance of specific weed control practices on the development of pest infestations and damage to sorghum and maize in production systems in different regions.

Since sorghum and maize are planted after the onset of the rainy season, emerge after the noncrop vegetation has become infested with the "langosta" and are damaged excessively by the lepidopterous larvae that move from the noncrop vegetation onto the crop plants. Consideration should be given to synchronized crop planting with emergence and establishment of noncrop plants in fields prepared for planting. This would delay planting. The practice of delayed planting would be difficult to implement as the farmers are urged to plant soon after the first rain to ensure good seed germination and plant stand establishment. As the "langosta" cause severe damage to sorghum and maize, the benefit of weeds in reducing pest damage to crops is likely to outweigh any reduction in crop yield due to weed competition. Information on the impact of delayed planting in relation to weed population and "langosta" species diversity and density will define these practices for "langosta" management in intercropped sorghum and maize.

Insecticides have been the immediate choice by farmers financially able to afford this control practice for the "langosta" lepidopterous complex. However, the resource poor farmer has "langosta" pest management options available that are financially affordable for sorghum and maize subsistence farming practices.

ECONOMIC EVALUATION OF IPM

On-farm systems were evaluated for integrated management of the "langosta" lepidopterous pest complex on sorghum and maize in the study area in southern Honduras. The IPM practices included planting date, weed management and insecticide application. A combination of delayed planting (5-10 days after emergence of weeds) and weed control (10-14 days after crop emergence) allowed the crop seedlings and early whorl stage plants to escape economically damaging early infestation by the "langosta" defoliators. The "langosta" larvae infested the preferred noncrop vegetation in the production fields before moving onto the sorghum and maize. This allowed the crop plants to grow past their early, very susceptible growth stages. A recommended insecticide was applied if the larval threshold reached 40% infestation. Improved sorghum cultivars with some levels of resistance to fall armyworm and early maturing maize hybrids are recommended in the crop management systems. These crop characteristics allowed the plants to develop in a shorter period of time reducing the time that the crops were in growth stages extremely vulnerable to attack by the defoliators. Seed treatment with insecticide provided some protection to seedlings and early whorl stage plants against these "langosta" and some other damaging insect pests.

The IPM systems evaluated were shown to increase sorghum production by 20% and maize production by 35% in the on-farm study. This increase may be translated to an increase in farm income of 18% and 30% for sorghum and maize, respectively.

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