Philipp. Ent. 16(2): 129-145 ISSN 0048-3753 OCTOBER 2002

RECOMMENDATIONS FOR THE MANAGEMENT OF MAJOR ARTHROPOD PESTS OF SUGARCANE AND CORN

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ABSTRACT

The most recent management recommendations for arthropod pests of sugarcane and corn was discussed and summarized. In sugarcane, the most dominant and most destructive insect pests are the white grubs, *Leucopholis irrorata* (Chevrolat) and the sugarcane borers namely: *Tetramoera schistaceana* Snellen and *Chilo infuscatellus* Snellen. On the other hand, the Asian corn borer (ACB), *Ostrinia furnacalis* (Guenee) is still the major hindrance to successful corn production in the Philippines.

For white grubs in sugarcane, community-wide campaign on beetle collection for about three weeks starting from the onset of beetle emergence significantly reduces the number of adults that will lay eggs for the next season. Collection and subsequent destruction of white grubs during tillage operations will help reduce white grub infestation. In addition, thorough cultivation of cane fields exposes white grubs to general predators like birds, earwigs and fire ants and also inflicts physical damage to the grub. The use of insecticides is the most common method employed by sugarcane growers against the insect. Proper timing of insecticide application is highly necessary to coincide with the abundance and susceptible stage of the grubs to ensure effective and efficient control. In areas in Luzon where grubs are known to be abundant, the recommended granular insecticides are applied along the furrows if planting is done in June. If planting is done earlier, insecticides are still applied in June to coincide with the susceptible stage of the pest.

For the sugarcane borers, the most practical and cheapest method of control is through the field releases of *Trichogramma chilonis* Ishii. *Trichogramma* are generally released in the field when cane plants are about 1-3 months old. Releases are carried out eight times at the rate of 60-80 cards per hectare (96,000-120,000 parasitoids). *Trichogramma* are released twice a week for the first four releases and at weekly intervals for the last four releases. At present, *Trichogramma* cards are available in the seven rearing laboratories of the Philippine Sugar Research Institute (PHILSURIN) and given free to growers who are members of the mill district development centers.

In corn, research is primarily focused on the management of ACB, the most destructive insect pest of corn. The most widely practiced cultural method of control is synchronized planting. Higher yields were obtained when corn is planted early in the season and any delay in planting caused a corresponding marked yield reduction. The field releases of *Trichogramma evanescens* Westwood based on ACB egg mass monitoring is the major management strategy employed against the pest. If there are 3-5 ACB egg masses per 100 plants at 20-25 days after planting, 70-100 *Trichogramma* cards are released per hectare. If percentage egg mass parasitism is less than 20%, field releases of *Trichogramma* are continued at weekly intervals for 2-3 times. If 40% of the plants showed symptoms of ACB damage, then granular/systemic insecticides are applied directly into the whorl or the plants are sprayed with microbial insecticide like *Bacillus thuringiensis*. The earwigs, *Euborellia annulata* (Fab.) which prey on ACB egg mass, larvae and pupae can be released 2-3 times at weekly intervals starting at 25-46 days after planting. Likewise, the flower bug, *Orius tantillus* (Motschulsky) which is also being mass reared in the laboratory, is a voracious feeder on egg mass and small larvae. The population of *Orius* can be enhanced in the field by planting spiny amaranth, *Amaranthus spinosus* along the periphery of the corn field.

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Successful management of ACB hinges on the mass production of biocon agents namely: the *Trichogramma, Orius* and earwigs. If these biocon agents could be made available to farmers at rearing laboratories located throughout the major corn growing regions, then ACB will no longer be a menace in corn production.

Key words: White grubs, sugarcane borers, Asian corn borer, *Trichogramma,* pest management, biological control.

INTRODUCTION

Sugarcane and corn are two of the most widely grown crops in the Philippines. Successful production of these crops is often beset with several problems with insect infestation as one of the most important. Like other crops, sugarcane and corn are attacked by several arthropod pests from planting until harvest.

The most common method of controlling arthropod pests is with the use of synthetic insecticides. However, due to the side effects of the continued use of insecticides, researches on the management of arthropod pests by other means were undertaken. This paper presents the most recent management recommendations against arthropod pests of sugarcane and corn.

MAJOR INSECT PESTS OF SUGARCANE

White Grubs

The importance, nature of damage, monitoring and management of white grubs in sugarcane were discussed in detail by Quimio *et al.* (2001). White grubs are highly destructive to sugarcane in the Philippines. Several species of beetles are associated with sugarcane (Gabriel, 2000). The most common and most destructive is the "June or toy beetle", *Leucopholis irrorata* Chevrolat. These beetles are locally called "salagubang" (Tagalog) or 'labug-labug" (Cebuano) while the grubs are called "ulalo" or "uok" in Tagalog, "tatad" in Pampango or "buc-can" and "bunlod" in Cebuano. Other beetles include several species of *Holotrichia, Anomala, Adoretus* and one species of *Oryctes*.

L. irrorata is considered a menace because of its voracious root-feeding habit. The grubs, the immature stage of several species of beetles, live most of their lifetime in the soil. Detection of the pest grub is not easy because of its subterranean habit. After living most of their life underground, the grubs emerge as full-grown beetles immediately after the first heavy rain in May or June. By the time the grubs become adults (or beetles), their food preference shifts to leaves of trees making them virtually harmless to sugarcane. However, the seemingly harmless beetles, are responsible for producing eggs that become the succeeding batch of grubs that will re-infest the existing cane plants in the field.

Damage to sugarcane is enormous as the grub enters the final growth stage. The full-grown grub reaches its biggest size and is equipped with well-developed, powerful mandibles capable of chewing tough, mature roots. In severe infestation, not only the roots but also the base nodes of cane plants are eaten up, rendering the plants severely stunted, losing anchor and dislodged from the soil (Fig.1). Eventually, the cane plants dry up and die prematurely. Cane yield on a six month-

Figure 1. The white grubs (top) and their nature of damage: roots and cane stems eaten up (Tuy, Batangas) (bottom) (from Quimio *et al.* 2001).

old crop can be reduced by 60% (roughly 30 tons cane/ha) based on one grub/stool assessment (Tiangco & de Ocampo, 1992). Crop damage is not conspicuous during the early stage of infestation but when the visible signs show up, actions for remedial measures to counter the damage often become too late and/or impractical.

As early as 1910, Merrill & Banks reported serious infestation in Negros. Uichanco (1927) reported grubs rampant among lowland haciendas stretching from Manapla in southern Negros to Kabankalan in the south. On May 28, 1930 at La Carlota, about 2,625,272 beetles were collected and on May 31, 1931 (La Carlota), about 1,887,316 beetles were also collected, belonging to species *L. irrorata*, *Lepidiota* sp., *Stephanopholis philippinensis* Brenske, *Holotrichia* sp. In 1957, Saplala surveyed several mill districts and reported the following grub infestation:

Negros Occidental:
Victorias - 85 hectares infested; 1,700 piculs sugar lost
Hawaiian-Philippines – 350 has; 7,609 piculs sugar lost
Talisay-Silay – 200 has; 4,304 piculs sugar lost
Bacolod-Murcia - 250 has; 5,010 piculs sugar lost
Ma-ao – 300 has; 5,916 piculs sugar lost
La Carlota – 500 has.; 11,650 piculs sugar lost
Binalbagan-Isabela – 600 has; 13,320 piculs sugar lost.
Cebu: February, 1931: Bogo Medellin Milling Co., Cebu.
Panay: October, 1930: Panay Central in Sara-Ajuy, Pilar; Santos-Lopez Central in Barotac Nuevo.
Luzon: White grub occurrence has been a perennial problem in most mill districts (Lopez & Pegenia, 1964). In Batangas, about 71.9 hectares, affected areas (in 1930s) in the towns of Balayan, Calaca, Nasugbu, Lian and Tuy. Also in Pampanga Sugar Development Co., Pampanga, (1930); in 1927 Uichanco reported infestation in Luzon cane fields along riverside in Cabuyao, Laguna and Marauoy, Lipa City. In 1992, "Operation Salagubang" yielded about 2.5 million beetles at the Don Pedro mill district (Tianco, unpublished paper); severe infestation was noted in Tuy, Batangas with about 30 has infested in 1999 (Quimio, personal observations).

Control Strategies Against White Grubs

1. Cultural and physical control

Cultivation. Thorough cultivation of sugar cane fields exposes grubs to general predators like birds, earwigs and fire ants. Collection and subsequent destruction of white grubs during tillage operation will help contribute in the reduction of white grub population. Deep plowing, besides exposing grubs and pupae to predators, also inflicts physical damage to the pest. Grubs are very sensitive such that even slight physical abrasions and exposure to the sun would be sufficient to kill them.

Weeding and sanitation. Grubs feed not only on sugarcane roots but also on weed grasses and plants with fibrous roots, and on alternate crop hosts. Removal of these hosts should be regularly done.

Irrigation. One of the reasons why grubs are seldom found in waterlogged areas and in clay soils but common in sandy loam or alluvial soils is that too much water drowns the grubs. If irrigation facilities are available, flooding the field will help reduce grub population. Results of survey in Lian, Batangas showed that about 20-35 percent grub mortality was monitored in flooded areas after an extended rainfall (Quimio *et al.*, 1999).

Beetle trapping. Beetles can be caught in traps. Although generally used as a monitoring tool, trapping could be useful in reducing beetle population. There are two types of traps that can be used namely: the use of white light and the use of attractant baits like red chillies or fermented barks of certain tree species.

a. Light traps (preferably white light, ≥150 watts) are set along corners of the sugarcane field and/or close to trees such as mango, sineguelas, or tamarind. Then a wide basin half-full of water, with a pinch of detergent, is placed beneath the light trap as catchment for the attracted beetles. However, the light trap may also attract beneficial insects, therefore this trap should be used in areas where the natural enemy population is low.

b. Attractant-baited traps.
b.1. Bark-based attractant. Beetles are normally active at dusk and can be collected easily by lures or baits made out of fermented barks of local tree species such as "aratiles" (*Muntingia calabura*), "anabu" (*Melochia umbellate*). Farmers in Northern Philippines particularly in Cagayan province, traditionally use the trap (called "keddeng" or "imod") to attract newly-emerged beetles mainly for cooking them into a special recipe. The bark-based attractant trap can be prepared as follows: 1) bark strips are taken from the trees and large branches of either "aratiles", "annavu" or "vuknung" tree, 2) barks are submerged and covered fully with mud in canal ditches to allow rotting or fermentation, 3) after at least two weeks, the barks are removed from the ditch and washed under running water to reduce the mud sticking on the fiber, 4) bark strips are then spread to air-dry, 5) a small amount of vinegar (optional) is sprayed on the strips and then stored inside a clean plastic bag while not yet being used, 5) at dusk, the bark strips are tied on pairs of bamboo poles near cane fields, and 6) the beetles attracted to the strips are collected and then killed.

b.2 Chilli-based attractant. Some farmers in Central Luzon, Philippines (Quimio, personal communication, 1999) and in Indonesia (Jongeleen & Mahrub, 1979), used bamboo leaves laced with macerated red chillies, as attractant bait for beetle collection. Red hot peppers are macerated in mortar and pestle and the paste is used as bait for attracting beetles. The macerated chilies are spread on bamboo leaves tied together to form a bundle. The bundles are raised on two-meter poles placed near cane fields to attract emerging beetles. The attracted beetles are also collected for food.

Beetle collection. Besides trapping, beetle collection from host trees can also be done. Collection of beetles during the early weeks of beetle emergence will reduce beetles that will subsequently breed and produce the succeeding generation of grubs. June beetles are inactive during daytime and even the slightest shaking could easily dislodge them from the trees. Large nets or sacks placed under host trees before shaking the branches facilitates collection of the beetles falling on ground vegetation. Collected beetles are killed by keeping them in tightly sealed bags or containers.

2. Biological Control

Conservation of existing parasites and predators. Grubs are preyed upon by a variety of general predators associated with sugar cane like ants, earwigs, predaceous beetles and vertebrates such as bats and birds including owls. Parasitic wasps that prey upon grubs in several sugar cane regions should be conserved by protecting their natural habitat or augmented to reduce grub populations in areas where the pest is widespread.

In Occidental Negros, for instance, 10 species of scoliid wasps were reported attacking grub species on the island (Lopez, 1932). In the early 1930s, *Campsomeris* (*Campsomeriella*) *collaris quadrifasciata* (Fabr.) was imported by Queensland, Australia for grub control and consequently, two Australian scoliid parasitoids were imported from Queensland into Negros that same year. In March, 2001, two of these parasite species namely, *C.* (*C.*) *c. quadrifasciata* (formerly *Campsomeris aureicollis* Lepeletier) and *Campsomeris* sp. nr. *reticulata* were both recovered in a sugarcane field attacking *L. irrorata* in Valencia, Ormoc City. About 20% of the collected grubs (n = 35) were parasitized (Quimio, unpublished data).

Use of fungus species for reducing grub population. Fungi pathogenic to grubs are relatively easy to mass-produce, have no reported adverse effects to plants and animals, no development of resistance reported and are potentially sustainable. Commercial formulations are available abroad but some of our local strains are also pathogenic to the grubs (Braza, 1990; Santiago, 1999).

Two species of fungi, *Metarhizium anisopliae* (Metsch.) Sorok. and *Beauveria bassiana* (Bals.) Vuill., were found pathogenic to *L. irrorata* grubs (Braza,1990; Santiago, 1999). In a laboratory experiment (Braza,1990), a strain of *M. anisopliae* isolated from *L. irrorata* caused 73% grub mortality rate. The fungus, however, has a slower effect compared to insecticides with peak mortalities occurring three weeks after fungus infection (Braza, 1990; Rombach *et al.* 1986).

Several strains of the two fungi were tested at the National Crop Protection Center (NCPC) against the larvae of *L. irrorata* and the strain very pathogenic to the grub was identified. In a laboratory test (Santiago, 1999), *B. bassiana* caused higher grub mortality compared to grubs treated with *M. anisopliae*. *B. bassiana*, the white muscardine fungus, is pathogenic to some agricultural pests including the grub species *L. irrorata*.

3. Chemical control

Success in the chemical control of white grubs is very variable and sometimes unstable. Timing of application, efficacy and proper delivery of the insecticide to the target grub species are some of the factors affecting effectiveness. Generally, the first and second instars are more susceptible than the third instar grubs because older grubs have tougher integument and are located at the lower sub-soil. To effectively control white grubs in sugarcane, the following pointers are recommended:

a. When planting in June, apply any of the recommended insecticides (Table 1) evenly along the furrows at recommended rates before planting canes,

b. When planting is done earlier, insecticide application should still be done in June to coincide with the susceptible stage of the pest and to have an effective and efficient control of grubs. Before applying granules, a furrow should be made first along the rows of cane plants with active infestation of grubs. Then, cover the chemicals with soil.

Management Options for White Grubs

Once white grubs become established in an area, the insects will be quite difficult to control. Application of insecticides, including the more selective biological insecticides, helps alleviate symptoms of pest outbreaks but only as a short-term solution to the problem. Current developments in crop protection suggest the integration of control approaches that are economical and practical to achieve a more or less sustainable control of the pest.

Table 1. Recommended insecticides against cane grubs.

Common Name	Trade Name	Recommended Rate (kg. a.i./ha.)	Amount of Product/Ha
Carbofuran	Furadan 3G	2	66.7 kg.
Cadusafos	Apache 10G™	1	10.0 kg.
Chlorpyrifos	Lorsban™ *	1	2.0 L.
Fipronil	Regent 0.3GR™ **	0.06 - 0.09	20-30 kg.

* Applied as soil drench at the furrow during planting by mixing with 100-200 L. of water.
** Conditional approval given by Fertilizer and Pesticide Authority.

An integrated management approach based on field experiences and outputs from research provides options that combine biological, physical, cultural, and chemical strategies. Farming systems that increase organic matter on the soil surface like stubble retention, application of organic fertilizers or soil ameliorants will encourage decomposers and ultimately increase the numbers of general predators. Allowing an increase in general predators and parasitoids may result in less need for insecticide application. Augmentation and conservation of natural parasites and predators like scoliid wasps, earwigs and predatory beetles will work harmoniously with cultural farm management and other bio-control tactics. The use of resistant host plants and fostering natural enemies by utilizing appropriate cultural practices may be viewed as long-term pest control or preventive strategy.

Beetle collection conducted before the breeding season reduces the number of adults that will lay eggs for the next season, an approach that could be combined with any of the strategies aimed to reduce succeeding grub infestation. Collection and destruction of beetles was tested and advocated even in the past and community campaigns proved effective in reducing grub damage in sugarcane districts before World War ll, particularly in Batangas and Negros Occidental (Otanes, 1950). This practice was revived in 1992 at the Don Pedro mill district and its impact, in combination with insecticides, was evaluated by NCPC with the Philippine Sugar Research Institute (PHILSURIN) funding. Beetle collection had the highest cost-benefit ratio as compared with insecticide treatments (Quimio & Ceballo, 1999). Community-wide campaign on beetle collection for about three weeks starting from the onset of beetle emergence, if implemented and sustained, will lessen the impact of grub infestation in problem areas.

Farm management systems could be integrated with the pest management system as a novel approach to the grub problem. In such systems approach, it is unlikely that a single method of control is to be sustainable. Instead, multiple control measures should be integrated. While not excluding insecticides as a control option, a number of different control measures are potentially feasible options that could be considered while trying to integrate those that are currently available (Dent,1997).

Sugarcane Borers

The other group of insect pests that are highly destructive to sugarcane are the sugarcane borers. The sugarcane borers (SCBs) are also highly destructive insect pests of sugarcane in the Philippines. There are at least two most dominant species of stemborers attacking sugarcane namely: gray borer (*Tetramoera schistaceana* Snellen) and the striped stem borer (*Chilo infuscatellus* Snellen). Young cane plants that are 1.5 to 4 months of age are highly susceptible to borer infestation causing deadheart injury (Fig. 2). Infestation may range from 50 to 73% and under heavy infestation especially during dry season, tillering is greatly reduced. When primary and sub-tillers are attacked, there is uneven growth and maturity is delayed by one to two months. It is a well-known fact that immature canes have lower sucrose content and consequently much lower yield.

The SCBs are difficult to control using synthetic insecticides. In addition to the unwanted side effects of insecticide applications, chemical control against SCBs is becoming more expensive nowadays. Fortunately, the use of *Trichogramma chilonis* Ishii against sugarcane borer had already gain tremendous acceptance by the planters. The periodic releases of *T. chilonis* resulted in increased parasitization of SCBs to about 60 to 80 percent (Alba, 1978). The supply of good quality of good quality *Trichogramma* is a major bottleneck in the area-wide utilization of this effective parasitoid. Fortunately, one of the offshoots of the NCPC project on "Integrated Management of Sugarcane Borers" (Javier & Gonzales, 2000) which was supported by Philippine Sugar Research Institute (PHILSURIN) is the construction of seven *Trichogramma* rearing laboratories in the Visayas and Mindanao. Therefore, *Trichogramma* strips are being mass produced by PHILSURIN and are given free to sugarcane growers who are member of the Mill District Development Council (MDDC) In this way, releases of *Trichogramma* could be synchronized with the abundance of SCBs.

Since the field releases of *T. chilonis* is the most practical and cheapest method of controlling SCBs, there is a need to monitor the sugarcane borer population in the field. The population/infestation of SCBs in the field can be established through visual counts of eggs/egg masses, larval and adult counts and incidence of deadheart.

Monitoring of Eggs/Egg Masses

The egg which is still non-destructive is the best stage to simulate the potential damage of the pest to the cane plant. Likewise, when planning for *Trichogramma* field releases and when evaluating the effectiveness of *Trichogramma*, it is necessary to monitor borer egg population (Javier & Gonzales 1999). It is quite difficult to monitor the sugarcane borer eggs especially when they are laid singly (e.g. gray borer) than when eggs are laid in mass (e.g. striped stemborer, top borer, pink and white stemborers). The whitish scale-like eggs of gray borer are laid singly or in batches of up to 13 on the leaves and leaf sheaths while egg mass of striped stem borer are laid on the underside of the leaves. It is important to note that only those eggs that are devoid of scale coverings (e.g. gray borer, striped and pink stemborers) can be parasitized by *Trichogramma).* On the other hand, *Trichogramma* are unable to parasitize those eggs that are protected

Figure 2. Larva of striped sugarcane borer, *Chilo infuscatellus* (left) and its characteristic deadheart injury to cane seedlings (right).

by scale coverings (e. g. white and top borers). However, there are other species of parasitoids that are associated with these stemborers such as the *Telenomus* and *Tetrastichus* (Alba, 1986).

Steps in Monitoring Eggs/Egg Masses of Sugarcane Borers

1. Define the sample area by dividing a hectare of sugarcane field into 10 sampling rows (furrows). Exclude plants from the outer 10 m peri-phery for sampling.
2. Randomly sample 10 hills (1 plant per hill) per row for the presence of sugarcane borer egg/egg mass starting at 1 month after planting. The distance between hills should be about 10-15 steps. Sample a total of 100 plants in a hectare sugarcane field.
3. If there are 10 eggs of gray borer and/ or 1 egg mass of striped stem borer per 100 sample plants, release *T. chilonis*.
4. If egg/egg mass counts are less than 10 eggs/1 egg mass per 100 sample plants, continue monitoring at weekly interval until three months after planting and release *Trichogramma* when needed. The density of egg masses per 100 plants can be converted to density per hectare depending on the total number of hills planted per hectare.

Field Releases of *T. chilonis* Against Sugarcane Borers

T. chilonis are generally released in the field when cane plants are about one to three months old. Releases are carried out eight times at the rate of 64 to 80 cards per hectare (96,000 to 120,000 parasitoids) as shown in Table 2. *Trichogramma* are released twice a week for the first four releases and at weekly interval for the last four releases. They are released either as pupae (6-day-old Tricho cards) or as adults (adults emerge from the cards are about 7-8 days after parasitization). It is easier and more convenient to release pupae but they are more prone to ant predation.

Table 2. Schedule of field releases of *T. chilonis* sugarcane field infested with sugarcane borers at about 30 days after planting (DAP).

Number of Release	Time of Release/Days After Planting (DAP)	No. of Tricho cards needed per release per hectare
First	30	8 – 10
Second	34	8 – 10
Third	37	8 – 10
Fourth	41	8 – 10
Fifth	48	8 – 10
Sixth	55	8 – 10
Seventh	62	8 – 10
Eighth	69	8 – 10
TOTAL		**64 – 80**

Steps in the Field Releases of *T. chilonis* Against Sugarcane Borers

1. From one corner of a hectare sugarcane field, walk 30 paces (20 meters) along the periphery. Again, make another 35 paces (25 meters) going inside the field along the furrow. This is the first release point. From the first release point, count another 35 paces for the second release point and another 35 paces for the third release point. From the third release point, walk 40 (30 meters) paces across the furrows for the next three release points, then to the last three release points as indicated in Fig. 3. There are about nine release points per hectare.

2. The Tricho cards(6th day-old) are clipped/stapled under the leaf surface with the parasitized portion of the card placed face down.

3. When *Trichogramma* are to be released as adults, it is advisable to transfer the Tricho cards in clear and clean bottles to observe adult emergence. Open the cover of the bottle and allow the adults to fly out of the bottle while walking along the furrows as indicated in Step number 1.

4. Release *T. chilonis* early in the morning or late in the afternoon.

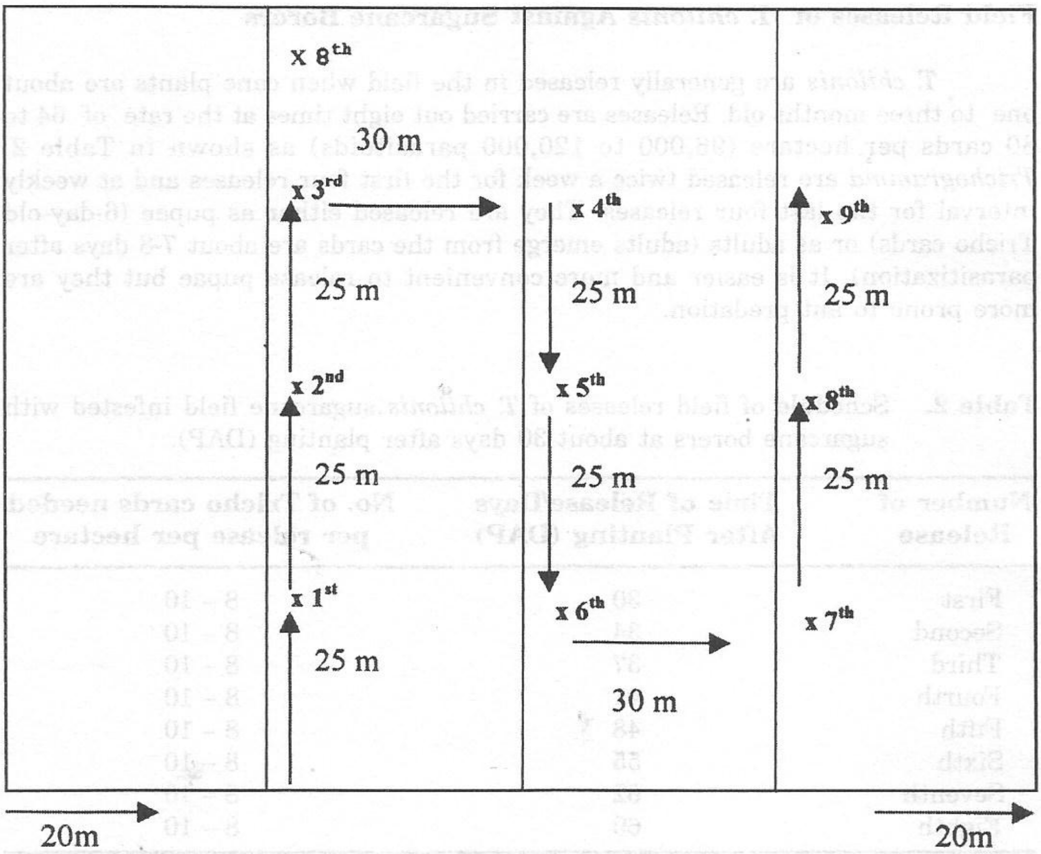

Figure 3. Sketch of *Trichogramma* release points in a hectare of sugarcane field.

MAJOR INSECT PESTS OF CORN

Insect infestation is the major constraint to successful corn production. These insect pests generally infest all growth stages of the plant in the field. Gabriel (2000) recorded more than 60 species of insects feeding on corn Fortunately, only about eight species are economically important (Table 3).

Studies in corn is primarily directed against the Asian corn borer (ACB), *Ostrinia furnacalis* (Guenee), the most destructive insect pest of corn in the Philippines and in Asia in general. ACB was found to reduce corn yield by as much as 20-80% (Sanchez 1971; Gabriel 1971; Morallo-Rejesus *et al.* 1982a, b; Morallo-Rejesus & Punzalan, 2001). Basic studies on the biology, ecology, yield loss assessment and on component control tactics which are the pre-requisites for the development of rational and sound pest management strategies had already been conducted in corn.

There are voluminous studies on the management of ACB especially on the use of synthetic insecticides. However, due to the negative consequences on the use of and the rising cost of synthetic insecticides, more recent studies are geared towards the use of selective insecticides, biological, cultural and physical control methods.

Table 3. List of major insect pests of corn.

Common Name	Scientific Name	Order	Preferred Stage(s)
1. Corn seedling maggot	*Atherigona oryzae* Malloch	Diptera	Seedling
2. White grub	*Leucopholis irrorata* Chevrolat	Coleoptera	Seedling to mid-Whorl
3. Corn semi-looper	*Chrysodeixis chalcites* (Esper)	Lepidoptera	Seedling to mid-Whorl
4. Common cutworm	*Spodoptera litura* (Fab.)	Lepidoptera	Seeling to mid-Whorl
5. True armyworm	*Mythimna separata* (Walker)	Lepidoptera	Seeling to mid-Whorl
6. Asian corn borer	*Ostrinia furnacalis* (Guenee)	Lepidoptera	Early whorl to hard dough
7. Corn earworm	*Helicoverpa armigera* (Hubner)	Lepidoptera	Seedling to hard dough
8. Corn Leaf aphid	*Rhopalosiphum maidis* (Fitch)	Hemiptera	Late whorl to tasseling

The cheapest and the most practical method of controlling the Asian corn borer is through cultural control. Although cultural practice by itself seldom give satisfactory pest population reduction, when this control method is combined with other control tactics (e. g. use of resistant variety) will provide adequate defense against most insect pests. One of the cultural control methods of controlling ACB is by manipulating the time of planting. In this method, the most susceptible stage of corn to ACB attack do not coincide with pest population peak. Aside from reduction in the amount of insecticides to apply, the effect on beneficial arthropods are minimized. There are indications that the presence of weed species like *Amaranthus spinosus* around the cornfields could be practical and even necessary in managing ACB population. *A. spinosus* serve as refuge for predators like *Orius tantillus* and spiders which are voracious feeders of ACB. Counts of *Orius* and spiders showed that their population is higher when *A. spinosus* is planted within or around the corn plants than when corn is planted alone (Javier & Morallo-Rejesus 2001).

The major component of pest management strategy employed against the ACB is the field releases of *Trichogramma evanescens* Westwood., a major breakthrough in the biological control of ACB since the pest is being controlled before reaching the destructive larval stage. The field releases of *Trichogramma* is based on monitoring of corn borer egg masses starting at 20-25 days after planting (DAP). If there are 3-5 egg masses per 100 plants, 75 to 100 *Trichogramma* cards (containing 1,500 – 2000 parasitoids per card) are released per hectare. If percent egg mass parasitism is less than 20%, field releases of *Trichogramma* is continued at weekly interval for two to three times. Moreover, if monitoring indicates that about 40% (40 out of 100 randomly sampled plants) of the plants show symptoms of ACB larval damage, then granular/systemic insecticides are applied directly into the whorl or the plants are sprayed with microbial insecticide like *Bacillus thuringiensis* (e. g. Dipel, Thuricide, Xentari).

The earwig, *Euborellia annulata* (Fab.) which is one of the dominant predators in cornfield. The predator prey on eggs, larvae and pupae of most lepidopterous pests including ACB. Fortunately, the predator can now be successfully mass produced in the laboratory using factitious diet using a combination of dog food and corn cob at 1:1 ratio. The cost of production per earwig is six centavos (PhP0.06). The two and three weekly releases of earwigs starting at 25 to 46 days after planting in open pollinated variety and in sweet corn gave significantly much higher yield and net income than the control fields (Morallo-Rejesus & Punzalan 2001).

Another dominant and highly effective ACB predator is the flower bug, *Orius tantillus* (Motschulsky). The predator prey of eggs and young larvae of ACB and other lepidopterous pests and on thrips. *Orius* is being mass produced in the laboratory using mites and thrips but rapidly multiply in the field on spiny amaranth, *Amaranthus spinosus* (Navasero & Morallo-Rejesus 2001). A good stand of *A. spinosus* in the field could support about 150 nymphs and adults of *Orius* per plant. Field experiments showed that at 5-7 predator density per plant at about eight week after planting is sufficient to regulate ACB population.

The key to the success of IPM in corn hinges on the area-wide utilization of *Trichogramma, Orius* and earwigs by corn growers. If these biological control agents could be made available to farmers through the rearing laboratories and its satellite laboratories which are strategically located in the major corn growing regions of the country, then ACB will no longer become a menace in corn production.

The crop protection group of University of the Philippines Los Baños prepared the management guide for corn pests during their meeting in 2000. The management options were prepared based on the growth stage of corn and is listed in Table 4.

Table 4. Management Guide for the Management of Corn Insect Pests

Growth Stage	Target Pest(s)	Strategy/Remarks
Pre-Planting	Corn borer, corn seedling maggot & other insect pests	* Choose varieties resistant to local pests * synchronized planting
At Planting	Soil insect pests	* Hybrid seeds are already treated with insecticide which will prevent soil insects from damaging the seeds. * For open-pollinated varieties, apply granular carbofuran near the seeds at planting if needed against soil insects
Seedling Stage (1-19 DAE)	Corn seedling maggots	* May be a problem during wet season. Monitor field cutworm, corn semi-looper regularly. If infestation is greater than 10%, spray/apply any of the recommended insecticides.
	Cutworm, corn semi-looper	* The application of insecticide directed against the corn seedling maggot will also control these pests.
Early to Mid-Whorl (20-35 DAE)	Corn borer Corn earworm	* randomly monitor 100 plants per hectare. If there are 3-5 egg masses/100 plants, release *T. evanescens* at the rate of 75-100 cards/ha * repeat monitoring after 1 week and release *Trichogramma* when necessary * if *Trichogramma* is not available and if 50% of the plants are showing ACB damage, spray microbial insecticide like *Bacillus thuringiensis* (late in the afternoon).
Late Whorl stage (35-45 DAE)	Corn borer Corn earworm	* Follow recommendation for early to Mid-whorl.
Tasseling Stage (45-55 DAE)	Corn borer Corn earworm	* detassel 75% plant population (3 rows for every 4 four rows) before pollen shedding * if there is an average of 2 larvae per tassel on remaining plants with tassels, spray microbial insecticide
Silking to Maturity (75-115 DAE)		* Control strategies should not be initiated at this stage

CONCLUSIONS AND RECOMMENDATIONS

Community-wide beetle collection should be regularly done at the onset of beetle emergence to obtain significant population reduction. The subsequent developing grubs should be collected during land preparation and cultivation to lessen grub pressure on sugarcane. The scoliid wasp, earwigs and carabid beetles are generally abundant in the field, yet the potential of these biological control agents remain untouched. Likewise, two species of fungi, the *Metarhizium anisopliae* and *Beauveria bassiana* were found pathogenic to white grubs in the laboratory but large scale field evaluation has not yet been done. Studies on the potential of these biocon agents should be aggressively pursued. The insecticides recommended against white grubs had long been used to control the insect. Farmers claimed that these recommended insecticides are no longer effective against the white grubs. Therefore, new, promising and safe insecticides should be evaluated such that they will be available for farmers' use especially during pest outbreaks.

In general, sugarcane growers do not apply insecticides for the control of sugarcane borers. This practice is highly favorable to the action of natural enemies like the earwigs which are abundantly found in cane fields. If *Trichogramma* will be regularly released by farmers then there will be a great possibility that sugarcane borers will be reduced to non-damaging level. However, the practice of burning the cane fields prior to harvest will be highly deleterious to the establishment of the effective biological control agents.

In corn, there are indications that ACB damage is slowly being reduced below damaging levels. If the biological control agents like *Trichogramma*, earwigs and *Orius* will be available to farmers and its population will be conserved after field releases, then the use of insecticides could be reduced significantly.

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