INTEGRATED PEST MANAGEMENT STRATEGIES USED BY THE OIL PALM INDUSTRY OF PAPUA NEW GUINEA

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ABSTRACT

Since its inception, the oil palm industry in PNG has adopted an Integrated Pest Management approach to its insect and other pest problems avoiding, where possible, the spraying of pesticides. IPM puts the emphasis on biological control, plant resistance, planting practices and other non-chemical methods, rather that the use of chemicals, and requires a broad understanding of the pests to be managed. The grasshopper pest, sexava, is used as an example of IPM, showing how the knowledge of the pest is used for identifying control thresholds, monitoring of the pests and carrying out control using physical, cultural and biological methods as well as the precise and timely targeting of insecticides using trunk injection. Similar approaches are also discussed for rhinoceros beetles, bagworm and the management of weeds using biological control agents. Such approaches provide long-term solutions to pest problems and can considerably reduce the incidence of outbreaks, thus reducing costly inputs.

INTRODUCTION

General Introduction

The oil palm growing areas in PNG have all the potential insect pests that one would expect from areas where coconut and other palms grow in plantations or in the wild. These include major known pests of oil palm such as grasshoppers, stick insects, bagworms, nettle and slug caterpillars, skippers, cutworm, leaf miner moths, bunch moths, rhinoceros beetles, black palm weevils, cockchafers, taro beetles, leaf miner beetles, leafhoppers, aphids, mealy bugs and scale insects. In addition to the insect pests there can also be problems with rats, snails and weed pests.

The Entomology Section of PNG Oil Palm Research Association (PNGOPRA) advises the oil palm industry in PNG on their pest problems, carries out research on improving the management of the pests, and breeds up beneficial insects (parasites and other controlling agents) for release into oil palm growing areas to help manage pests.

This paper provides some examples of Integrated Pest Management (IPM) strategies used by the oil palm industry in PNG to manage pests and the processes involved in developing those strategies.

Integrated Pest Management

There are three major principles of IPM:

- keeping pests below economically damaging levels
- relying, wherever possible, on non-chemical measures to keep pest populations low
- selecting and applying pesticides in a way that minimizes adverse effects on beneficial organisms, humans and the environment.

IPM emphasises biological control, plant resistance, planting practices and other non-chemical methods and requires a broad understanding of the pests to be managed. A diagram of IPM strategies in relation to work undertaken at PNGOPRA is shown in Figure 1.

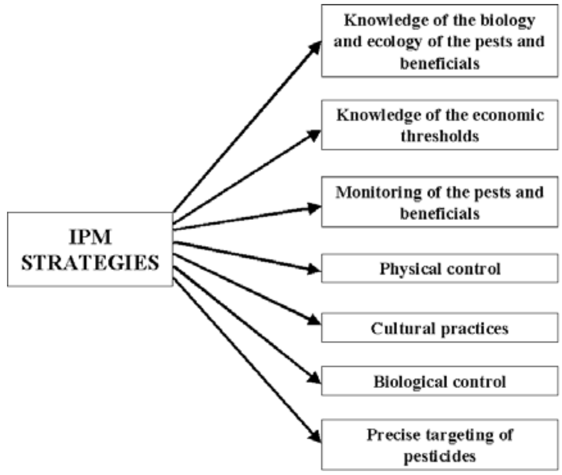

Figure 1

MAIN CONTENT

IPM of grasshopper pests

An example of using IPM strategies for the management of a pest is sexava. These are a group of long-horned grasshoppers (Tettigoniidae), which can defoliate oil palm in large outbreaks and can cause serious economic damage. They are the main insect pests of oil palm in PNG and constitute more than 80% of the reports of pest problems in oil palm in PNG each year. By applying the strategies laid out in Fig. 1, it is possible to effectively manage outbreaks of this pest. The relevant knowledge on sexava, which acts as a basis for IPM, is shown in Table 1.

IPM: knowledge of sexava	
Biology and ecology	• Slow development giving a long life cycle of six or more months • Poor mobility limiting outbreaks • Often move from natural host plants • Several known parasites and predators (beneficials) • Females may lay 100 or more eggs in batches of around 14 eggs. • Most eggs deposited in the ground, females have to come down from the crown to lay. • Initial egg diapause (arrested development) variable, producing hatching throughout the year • Also late egg diapause caused by dry periods • Late egg diapause broken by rainfall
Economic thresholds	• Thresholds based on defoliation levels not pest numbers. • Light defoliation tends to develop into moderate to severe damage unless parasitoids are present in good numbers • Moderate/severe defoliation reduces yield by up to 50% for two years • Can take up to five years to recover • Defoliation of upper fronds particularly damaging
Monitoring	• Outbreaks initially monitored and reported by harvesters, pruners and field supervisors • Damage levels assessed, defoliation maps and recommendations produced • Beneficials also monitored as part of the control decision process.

Table 1

With the knowledge from Table 1 it is possible to put together management strategies appropriate to the pest and can be summarised by examining the different types of control shown in Figure 1 individually and discussing what methods are used. Physical, cultural and biological control methods are combined to provide long-term regulation of low-level populations of sexava. Sometimes they have to be combined with chemical control when outbreaks occur which are not controlled by the non-chemical control methods by themselves.

Physical control

a. Hand collecting of sexava adults and nymphs from affected areas, particularly from young palms. This is good method when infestation levels are comparatively low.

Cultural control

a. Movement into palms from uncultivated areas can be reduced by removing natural host plants (coconut, *Heliconia* spp. etc.) from the vicinity of the oil palms.
b. Preference for shade means that it is important that oil palms are kept well pruned and kept free of old fronds that tend to hang down from the central cluster.

Biological control: egg parasitoids

A number of parasitoids are known from sexava eggs, mostly parasitic wasps (Hymenoptera). These can lay one egg into an egg of sexava which then clones into different numbers of larvae which feed inside the eggs and kill the host embryo. Two species have been recognised as being efficient parasites of sexava eggs and are use to help manage sexava build-ups: *Leefmansia bicolor*, which produces around 25 wasps per egg and *Doirania leefmansi* which produces around 250 per egg. The latter species has been shown to be able to find and parasitize eggs up to 2cm in the ground and also kill well developed embryos.

a. *L. bicolor* and *D. leefmansi* are reared in sexava eggs under laboratory conditions and then released into oil palm growing areas where low-level sexava populations are present. This helps to manage outbreaks.
b. Several million of these egg parasitoids are released into the field each year.

Biological control: internal parasitoids of sexava nymphs and adults

The Strepsiperan parasite *Stichotrema dallatorreanum* is found in the sexava pests *Segestidia novaeguineae*, *Sexava nubila* and *Segestes decoratus* on the mainland of PNG where they are known to suppress the build up of outbreaks. Work carried out by OPRA between 1995 and 2002 showed that the *Stichotrema* found around Popondetta appeared to be reproducing parthenogenetically thus excluding the complicated male life cycle (through ants). The latter was thought to be the reason that previous attempts to introduce the parasite onto the islands for coconut IPM had failed. Large numbers of sexava were infected and released (10,878 at more than 20 trial sites) into the oil palm growing areas of New Britain and New Ireland between 2000 and 2002. Monthly monitoring up to the end of 2002 produced very few returns and between July 2002 and November 2003, despite dissecting specimens from some of the release areas to look for immature stylops, no *Stichotrema* were found.

In November 2003 a report of light damage at Kabaiya (near Bialla in West New Britain Province) was followed up and over 30% of the *S. defoliaria* examined had adult *Stichotrema* protruding their cephalothoraxes out of the body of the hosts (seen as dark brown/black dots on the underside of the abdomen). Dissection of samples to look for immature stages (stylops) showed parasitism rates above 50%. The light damage, which would normally lead to moderate and severe damage, stayed the same over several months suggesting that the outbreak (over 300 Ha) had been suppressed. It was also noted that there was a considerable reduction in sexava numbers at the time when a large proportion of the *Stichotrema* were producing first instar larvae. This was because once *Stichotrema* produce their first instar larvae (up to an estimated 750,000) they die and kill their host in the process. Also deaths occur before this when there is multi-parasitism and the host cannot cope with the parasite load.

Subsequent surveys have shown that the distribution of *Stichotrema* in the Bialla area is quite widespread in smallholder plots and at Navo plantation.

a. Work has begun on infecting *S. decoratus* and *S. gracilis* using the parthenogenetic stock of *Stichotrema* from Bialla.
b. Redistribution of the parasitoid into other areas of Hargy Oil Palms and Bialla Smallholders has been initiated.
c. Regular collections of parasitized sexava are being made and released into Kapiura (NBPOL) where *S. defoliaria* is the major pest.
d. Local training encourages growers to do their own redistribution
e. It is hoped that *Stichotrema* will manage sexava outbreaks on New Britain as well as they do on the mainland as this will reduce the costs of control considerably.

Biological control: biodiversity management

a. In order to ensure good biodiversity within plantations and to help sustain the beneficial insects, controlled, targeted usage of herbicides and insecticides is encouraged.
b. Planting and/or encouragement of vegetation to sustain beneficial species of predators and parasitoids (i.e. the adults of the egg parasitoids) is encouraged.

Chemical control

The control methods described above help considerably to suppress upsurges of sexava. However there are circumstances where outbreaks of sexava can occur where chemical control is required and it has been important to understand why these outbreaks occur. PNGOPRA have shown that sexava eggs can accumulate in the soil over extended periods because they are in arrested development (diapause). This can be an initial, highly variable, diapause (16 days to 8+ months) which begins when the embryos are very young; or a late diapause, brought on by the dry weather, when the embryos are well developed. Eggs coming out of early diapause may develop up to close to hatching but then go into late diapause if it is dry. The longer the dry period, the greater the number of eggs accumulating in the ground waiting to hatch. When suitable rains break the dry period, the sexava eggs all hatch at about the same time producing a large increase in population (outbreak), which the parasitoids and predators cannot catch up with initially. Such outbreaks may therefore require chemical control.

a. By monitoring an outbreak, the area in which damage is occurring can be delineated (based on leaf damage). This allows the precise targeting of a systemic insecticide using trunk-injection in the area where damage is occurring.
b. 10ml of methamidophos is applied per tree into a single 1.5cm diameter hole, 15cm deep and drilled at a 45° angle into the trunk, 1m above ground. The hole is plugged to avoid infections getting into the palm and any dangers of external contamination. The work is done by well trained control teams.
c. By confining the insecticide to the palm, there is no impact on other non-target organisms.
d. The treatment is sometimes repeated after 12 weeks to control any sexava nymphs that have emerged from the ground after the effectiveness of the insecticide from the first treatment has waned (60 days).
e. The timing of the second trunk injections depends upon conditions outlined below.

Decisions on the use and timing of biological and chemical control of sexava

By examining samples of sexava collected from the field, it is possible to identify two types of population structure using morphometrics: (i) overlapping populations, which can gradually build up in an area if the conditions are right. Usually this type of population is suppressed by beneficials so the area is monitored if the damage is very light in order to see whether chemical control is really necessary. (ii) A mass hatch from diapausing eggs that have built up in the soil during a particularly dry spell.

a. If an outbreak from a mass hatch is discovered early, the population will consist of only two or three stages of nymphs that, because no egg laying is taking place, may only have to be controlled by trunk injection once.
b. In addition to checking the ground below palms for sexava eggs, it is possible by dissection to tell whether adults have already started laying eggs, if they haven't, then only one trunk injection may be necessary.
c. If adults have been laying eggs, a second trunk injection will be necessary to catch emerging nymphs.
d. The timing of the second control may depend on the proportions of eggs in early diapause and whether eggs go into late diapause or not, because if eggs are in diapause much of the subsequent hatching may be missed by controlling at 12 weeks. The second trunk injection is delayed as long as possible to maximise the control of hatching nymphs.
e. Egg parasitoids should not be released after a mass hatch as there would be few eggs in the ground.
f. *Stichotrema* should not be released during a severe dry season as the only population present might be in the form of eggs.
g. After severe dry seasons *Stichotrema* may have to be redistributed from areas where they have survived.

The timing of the different stages from a mass emergence is illustrated in the schematic life cycle shown in Fig. 2, which illustrates the expected times of the egg hatching of the next generation after a normal dry season (with sporadic showers) and a particularly severe dry season when prolonged diapause might be expected. Such knowledge, when used for control decisions, can considerably reduce the use of insecticides and can also be used to time the release of parasitoids.

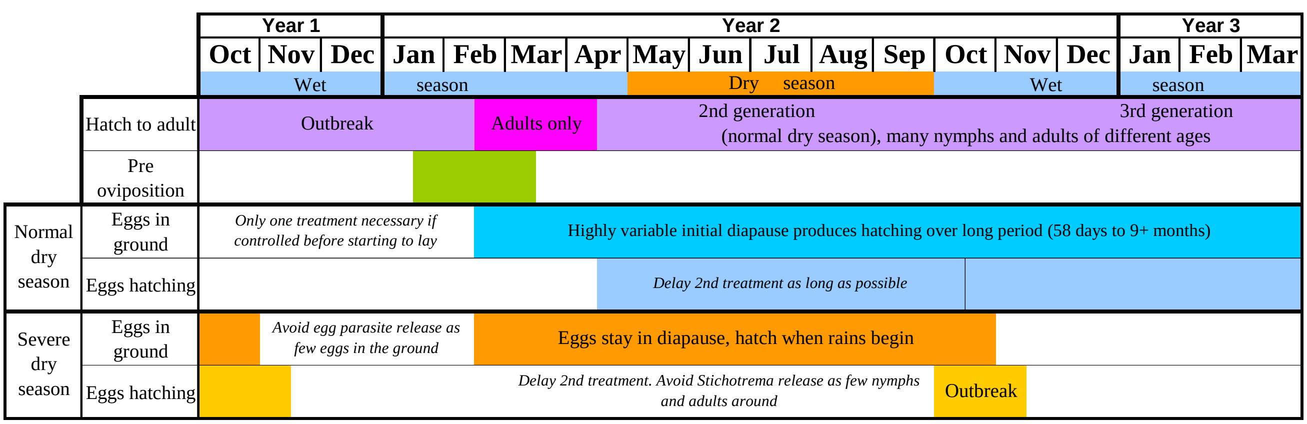

Figure 2

IPM of other pests

Similar IPM approaches are used for other oil palm pests such as rhinoceros beetles, which bore into the growing crown causing damage; bagworms that, like sexava, cause defoliation and some weeds such as Mimosa and Siam weed. The control measures used by the oil palm industry in PNG are summarised below.

Rhinoceros beetles

a. Ensuring that breeding sites such as decaying trunks are disposed of rapidly. This is also part of the strategy for managing *Ganoderma*.
b. Physical control can be affected by hand picking the adult beetles from their bore holes using a wire hook.
c. Experimentally it has been shown that a synthetic aggregating pheromone can be used to attract the beetles to traps and then the beetles can be infected with a baculovirus and released to pass on the infection.
d. Normally, no chemical control is required.

Bagworms

a. Hand collection from young palms.
b. Removal of natural host plants from the vicinity of oil palm growing areas.
c. Maintenance of good ground cover for beneficials.
d. Precise targeting of insecticide by trunk injection (using one treatment only).
e. Bagworms are particularly vulnerable to parasitoids, pathogens and predators so biodiversity management is important in suppressing outbreaks and control by trunk injection is very seldom required.

Weed pests

a. Psyllid bugs (*Heteropsylla spinulosa*) are being used to manage Mimosa.
b. Stem-galling flies (*Procecidochares connexa*) are being used to help manage Siam Weed (*Chromolaena odorata*).
c. As part of pest management in newly planted areas, a vigorous legume is used as a cover crop to out-compete weeds, provide nitrogen fixation and reduce soil erosion. Once the palms have grown and produce shade, the legume dies back and weeds, many of them beneficial, move in.
d. Herbicides are used to keep circles around the palms free from weeds. This allows the loose fruit, which is an indicator of bunch ripeness, to be clearly seen and is the catalyst for timely harvesting. Paths are kept clear to assist with inspections and to allow the harvesters easy access to the palms. Where the land is flat and accessible, paths are cleared using a tractor drawn cutter so only the circles are kept clear using herbicides. These practices help to ensure that beneficial weeds are present within the oil palm growing areas.

Overseeing pest control

All pest outbreaks on oil palm within PNG (excluding most weeds and pathogens) are monitored by the PNGOPRA Entomology Section and recommendations on control made. In addition all control by trunk injection has to be authorised by PNGOPRA and the controlling agent (methamidophos) is only allowed to be imported for oil palm trunk injection by the PNG Department of Environment and Conservation under this strict control. This helps to ensure that the integrated pest management techniques are fully utilised and that pesticides are used as a last resort.

CONCLUSION

Since its inception, the oil palm industry in PNG has adopted an Integrated Pest Management (IPM) approach to its pest problems, avoiding the spraying of insecticides and minimising the use of other pesticides. IPM approaches provide long-term solutions to pest problems and can considerably reduce the incidence of outbreaks. Such an approach helps to reduce costly inputs and is of particular benefit to smallholder producers who are important partners in palm oil production.

IPM is a strategy which may take decades to set up if previous control methods have affected the environmental balance, particularly in terms of building up and maintaining populations of parasites and predators. It is thought that the long term IPM approach in PNG has helped to suppress the overall level of the pests of oil palm despite them being present, as potential reservoirs, in coconut.