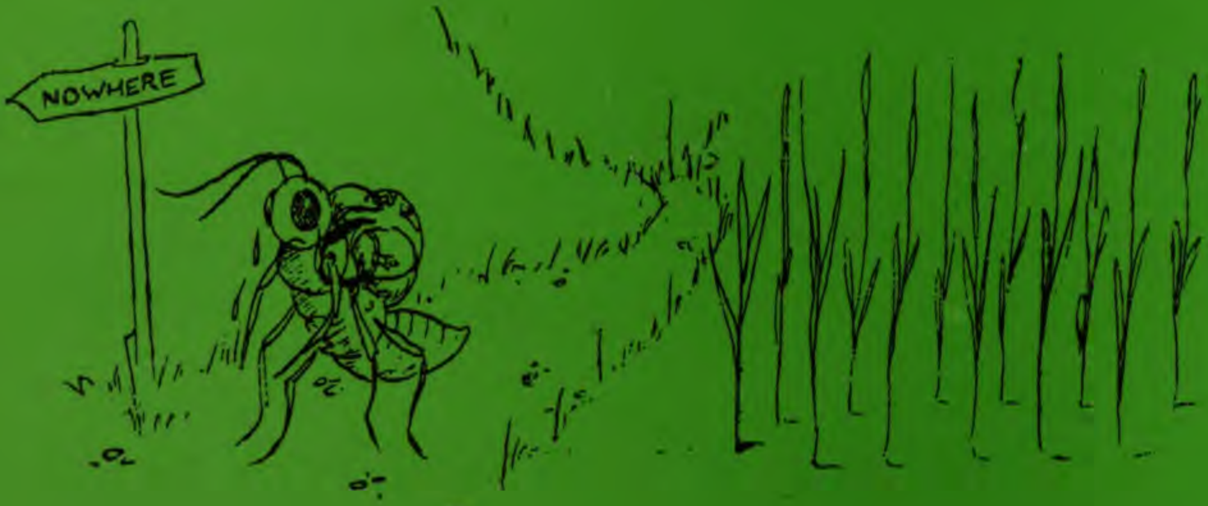
NTEGRATED PEST MANAGEMENT AND THE USE OF BOTANICALS IN GUYANA

R. PLUKE, D. PERMAUL, & G. LEIBEE



Illustrator: Sarah Hemingway

IPM Cases:

- *"Worms in fruit" - Sapodilla fruit fly*
- *"Chinese Writing" - Leafminers*
- *"Acoushi ant" - Leafcutting ant*
- *"Windows in cabbage leaves" - Diamondback moth*
- *"Ghandi" - Paddy bug*

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The authors wish to inform readers of this book that their best efforts were made to ensure that the facts are correct. However, they wish to point out that any application or use of treatment or chemical mentioned herein is the sole responsibility of the user. Neither the authors nor the publishers can be held responsible for any damage resulting from the use of materials or chemicals presented in this book.

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FOREWARD

Insects are an important and necessary part of this planet's natural diversity. Human beings are also part of that diversity. Our activities, in one sense, are the efforts we make to define and manage our position within that global picture. In terms of agricultural insect pests, our role is to manage the impact that these insect species have on our agricultural systems. Management of these agricultural pests should have a minimal negative impact on the broader relationships within our natural environment. This book is written with this in mind.

The book is a product of the project "Increasing Agricultural Production through the use of Natural, Environmentally-Friendly Pesticides", funded by the Canadian International Development Agency (CIDA) and implemented as a joint effort with VSO, IICA, UG and FAVA/CA. The objective of this project was to investigate the use of local plants and plant products (botanicals) for crop protection purposes. Present worries concerning the over-reliance and dangers of synthetic pesticides in Guyana prompted this examination of alternative control options.

In presenting the findings of the work, it was deemed important that botanicals should not be promoted as a direct substitute for synthetic insecticides. Doing so would have reinforced the unsustainable reliance on the "magic bullet" when looking for solutions to pest problems. Like synthetic insecticides, botanicals on their own do not provide sustainable solutions. For this reason the book has concentrated on presenting an integrated approach to pest management.

The book:

- presents and discusses the concepts and practical methodologies used in Integrated Pest Management (IPM) [Chapter 1];
- supports this by examining ways of integrating control efforts against some common pests of Guyana [Chapters 2 & 6];
- highlights Guyana's botanical diversity by describing the potential crop protection uses of 50 local plant species. Advice is also given for those who wish to lengthen this list of useful plant species [Chapter 5];
- takes a detailed look at synthetic insecticides and discusses their responsible management [Chapters 3 & 4].

It is hoped that this book will have a wide appeal. In particular we hope that those directly involved in pest management will be able to use it as a practical tool - not only for solving pest problems but also for changing attitudes about "pests" and to introduce more rational techniques for their management and for the use of synthetic chemicals.

ACKNOWLEDGEMENTS

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- We also thank the Ministry of Agriculture (Guyana) for plate 2.23 on the Pink mealybug and the Commonwealth Science Council (CSC) for giving us permission to use the line drawings in the book "A Guide to the Medicinal Plants of Coastal Guyana".

Finally, a heartfelt thanks goes out to the farming communities of Charity, the Pomeroon River, Wakapoa and Dartmouth who warmly offered their friendship and shared their invaluable experience. Personal thanks are extended to Connie Adams, Kenneth Da Silva, Roy George, the late Brother Young and all their families. There are many more.

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CHAPTER I INTRODUCTION TO PEST MANAGEMENT

1.1 Introduction

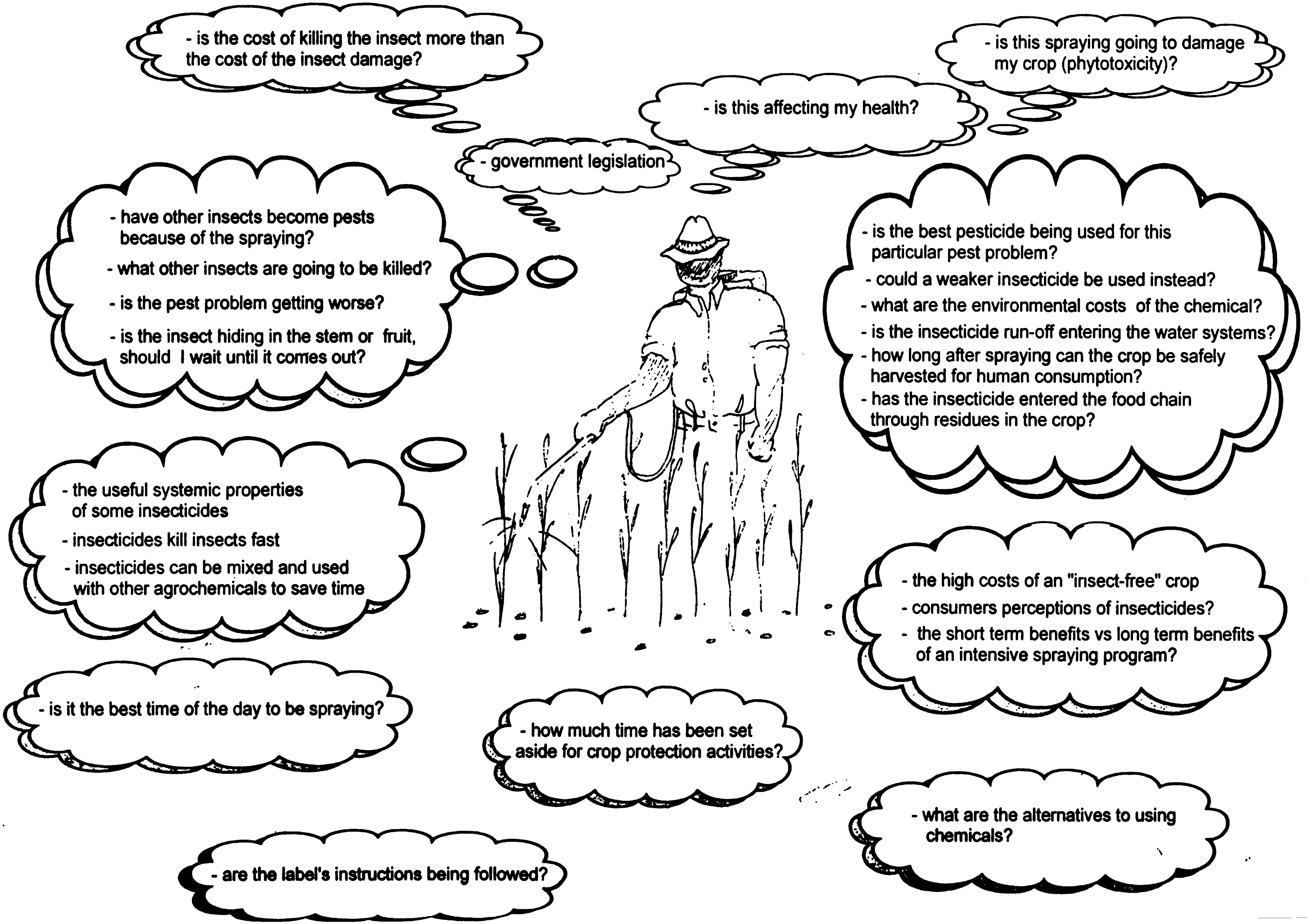
A pest can be defined "*as an animal or plant whose activities interfere with human health, convenience, comfort, or profits*" (Horn 1988).

For many people response to discovering insects in a crop is a "knee jerk" reaction. Insects have proved time and time again how devastating they can be and for this reason most people want to deal with insect pests fast and effectively. This explains why the use of insecticides is often the automatic response. The reality of a pest situation is, however, that if there is no preparation and thought before, during and after a control exercise, it stands a high risk of failing, irrespective of the method used. To give yourself the greatest chance of success, certain practical issues need to be addressed. These are dealt with in this first chapter but can be summarised as follows.

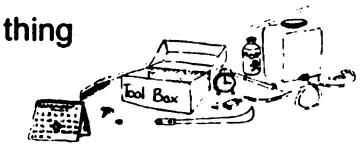
- Identify the actual **cause of the problem** in your crop. It may or may not be insects.
- If insects are found in a damaged crop it should not be automatically assumed that they are the cause.
  Of crucial importance is the **proper identification of the insect species** in your crop. Is it a known pest or is it just harmless?
- To be in the best position to make the right decisions you need early, **accurate information**. **Scouting** your crop for pests, disease and signs of damage will give you a good start. Once an insect with the potential of being a pest is identified in your crop, the situation needs to be monitored. **Monitoring** is important because you need to have an idea of the size and dynamics of the insect population to make accurate decisions.
- Predetermine the level at which an insect becomes a damaging pest and the level at which, economically, it is justifiable to take action against the pest. This is important to achieve an efficient control strategy. It may be that you do nothing. Monitoring and knowledge of the insect's biology allows you to set these **population thresholds**.
- **Decide** on the most appropriate control strategy. Use all available information on the pest, the farming system, the control options and the predetermined pest thresholds.
- Be aware of all the **control options** available and be in a position to use them correctly. Restricting oneself to the indiscriminate use of synthetic pesticides is undesirable. There is a wide variety of control options available. Many of the options allow you to take the initiative even before the insect pest is present.
- It is very important after a control event (whether any action is taken or not) to get feedback on what the control response has achieved. Assessment of the control response will affect what actions are next taken. To assist long-term control efforts **record keeping** should be an integral part of the integrated pest management process.

This approach to solving an insect pest problem is often referred to as **Integrated Pest Management (IPM)**. This concept is expanded upon further in this chapter. It is part of a larger approach termed "integrated farm management", which stresses that the various aspects of farming should not be viewed or dealt with in isolation. Each aspect impacts on another.

Figure 1.1: **What's on your mind when you spray?**



1.2 Integrated pest management (IPM)



Once a farmer has identified an insect pest he can then act. The easiest thing for him to do may be to throw a powerful insecticide into the knapsack sprayer and then spend a couple of hours in the field spraying. In an isolated situation, this may be the obvious solution; nothing at the moment kills insects with such efficiency and relative low costs as an appropriate insecticide - take Baygon's effects on sugar ants. Why then do crop protection specialists complicate the issue by making such statements as:

> **"pest management [is a] system that, in the context of the associated environment and the population dynamics of the pest species, utilises all suitable techniques and methods in as compatible a manner as possible and maintains pest populations at levels below those causing economy injury."** (Brader 1979).

How do we explain this? Remember, no act is in complete isolation. It is not just a matter of the insecticide killing the insect. Figure 1.1 illustrates some issues relevant to the simple act of using an insecticide. Some affect the farmer directly, some affect his business, others affect his local surroundings, or the environment at large. Sooner or later these factors will influence your crop protection decisions and activities. If there is no consideration of the influencing factors, a crop protection activity runs the risk of being wasteful and possibly even dangerous. While insecticides are more likely to be effective and, on the surface, fulfill the crop protection requirements, Figure 1.1 illustrates the underlying costs and concerns attached.

Through experience, successful long-term crop protection success is achieved by using a more integrated approach. The phrase "Integrated Pest Management (IPM)" has been coined to give a name to such an approach. The complicated definition of pest management given above is just one way of describing IPM.

Modern agricultural practices lead to alterations in the balance of nature. These alterations then cause further knock-on effects in the ecosystem in which the farming system is found. Sometimes these effects include a rise in numbers of certain important insect species. This increase in numbers could come about for a variety of reasons. It may be that the crops grown make an ideal food source for the insects. Alternatively the farming practices used may result in a decrease in numbers of other animals which normally eat the insects. Whatever the reasons, the increased numbers in these insect populations could pose a threat to the success of the farm were the insects to live or feed on the crop plants.

IPM seeks to redress the balance of nature by:

- **subtly adjusting various elements of the farming system**; and where necessary
- **providing low impact inputs into the system.**

These actions reduce insect populations to acceptable levels (as set by thresholds), whilst keeping long term economic and environmental costs as low as possible.

In all IPM programmes there are 7 major components to consider:

i. **identification** of the causes of crop damage;
ii. determination of the factors which regulate pest numbers and plant health. This is part of a general **information gathering** exercise and it should be as comprehensive as possible;
iii. **monitoring** of pest populations, their natural enemies and the environment. This should occur at all times on a farm.
iv. determining unacceptable levels of pest damage (i.e. **pest damage thresholds** and **economic injury levels**) as linked to crop protection decisions;
v. a **decision-making** framework which, using all relevant information available, determines the actions to be taken;
vi. **implementation of control measures** for the selective manipulation of the pest problem and
vii. further monitoring and assessment. **Record keeping.**

Highlighted here is the importance of obtaining information. The ability to understand and use the information is also central to a successful control program.

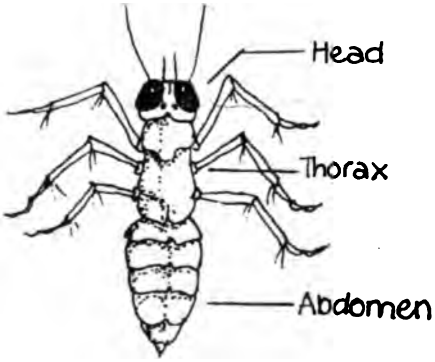
In Chapter 1 the components of IPM are discussed to show how each is integral to the process of developing an effective pest management response.

"What is that eating my plants!!!?"

1.3 Causes of crop damage and their identification

1.3.1 Insect identification

So, what is an insect and what does one look like. It would be easy if they all looked like this:



But insects don't all look alike, in fact there is more diversity of form in the insect class, than of any group of animals on earth. This is to be expected when there is said to be between 1 and 10 million different insect species. Since the experts are finding new species every week, they can afford to be a little vague. On land, insects are found everywhere and survive because of their adaptability and diversity.

So, what makes an insect an insect? All insects have 3 body parts, (head, thorax and abdomen), 3 pairs of legs (attached to the thorax), 1 pair of antennae, and often a pair or two of wings. These basic characteristics would seem to make insect identification easy. This unfortunately is not true. Exact identification of the kind of insect requires careful examination of characteristics such as number, texture and shape of wings and type of mouthpart. Modern techniques involve the examination of chromosomal material.

Below is a simplification of the taxonomic system used for the classification of insects:

Taxonomic Name	Common/Local Name & Examples
Collembola	Springtails
Odonata	Dragonflies (palmflies) & damselflies
Orthoptera	Grasshoppers, crickets, preying mantids, cockroaches & stick insects
Dermaptera	Earwigs
Isoptera	Termites (wood ants, hara hara)
Psocoptera	Book & bark lice
Mallophaga	Biting lice
Anoplura	Sucking lice
Thysanoptera	Thrips
Hemiptera	True bugs, (paddy bug, stink bug)
Homoptera	Cicadas (6 o'clock bee), hoppers, psyllids, whiteflies, aphids (bloodflies), scale & mealybugs (blight)
Neuroptera	Lacewings, antlions, etc.
Coleoptera	Beetles, (ladybird, weevils ,etc.)
Lepidoptera	Butterflies & moths
Diptera	Flies, (house fly, cow fly, mosquito)
Siphonaptera	Fleas
Hymenoptera	Ants, bees & wasps.

This gives you some idea of the complexity surrounding the task of determining what is an insect and what is not. When you see mealybugs (sometimes referred to as "blight") on your flower plants and a ladybird eating them, you would hardly imagine that they both belong to the same group of animals.

Identifying the insect on your crop is important. The first objective of any crop protection exercise, (and any problem-solving situation), is to identify the cause of the problem. Once identified the response to the problem can be planned. In Guyana, identification is made more difficult by the fact that the stable, warm environment has been perfect for the

survivial and development of massive numbers of insect species. It is thought that only a fraction of the insect species of the South American rainforest has been identified by science. Fortunately for the farmer or extension officer, most of the insects of agricultural significance have been identified in Guyana. In fact, the National Agricultural Research Institute (NARI), Mon Repos, has an excellent collection of insects.

"If it's not an insect, then what is it?"

While this book will largely focus on insects, it is worth mentioning some other causes of crop damage, reduced yields, or general poor plant health.

1.3.2 **Other damage factors** to be aware of

a. **Poor planting material:** when the plant parts (seeds, cuttings etc.) chosen for planting are innately not strong enough to do well.

b. **Poor choice of crop/variety:** if the plant type is not suited to the environment, then it is a waste of time planting it. This has been proven many times by the poor results obtained from free seeds given from overseas countries. If a crop variety has been bred to grow in a cold climate, then it is unlikely that it will reach its full potential or even grow at all in Guyana's hot climate. Alternatively it might be the soil type or water availability that makes a certain crop an unsuitable choice.

c. **Poor growing environment**: this is often related to the state of the soil (e.g. low nutrient levels, poor physical properties). Weather conditions can also contribute to poor yields. Heavy rain or strong winds can damage the crop and sometimes ruin it.

d. **Poor management of the crop**: this occurs when the grower doesn't take due care over the preparation, planting and husbandry of the crop. Has the seed material been planted too deep, too close together, or in soil that is too compact? Perhaps the field has not been dammed off properly to prevent flooding. It could be that the choice and application of an agrochemical was wrong.

e. **Disease**: this topic requires a book on its own. Diseases are most commonly caused by:

i. **fungi**; like the "mould" on old bread or the mushrooms ("jumby umbrellas") growing on rotting wood. *Sigatoka or Banana leaf spot is an example of this type of disease.* Fungal spores are minute and are readily moved in the air or water and they establish themselves on new hosts with ease.

ii. **bacteria** cannot be seen without a microscope. *Moko disease, a bacterial wilt, is an example of a serious bacterial disease.* The bacteria grow in wet conditions and disperse in water films and by rain splash. Some are transmitted from plant to plant by vector agents such as insects, birds and most importantly, man. Bacteria can also be moved on seeds and other planting material.

iii. **viruses**-causing disease are even smaller than bacteria. *The patchy pale patterning, (mosaicing), on red pea and black-eye peas is an example of this type of disease.* Their impact on a crop may take some time to recognise and unless the attack is early in a crop's development, the effects on yield are minimal. Viruses are spread when infected plant parts are planted. Sucking insects, such as aphids, (bloodfly), and whitefly are important in transferring viruses from plant to plant.

Diseases are usually identified by the symptoms they produce.

The preliminary disease identification usually is made using the symptoms produced – leaf curling, yellowing or rosetting for example. For sake of accuracy this initial diagnosis needs to be verified by the identification of the **causal** (disease) **agent** or pathogen. This is normally done by trained individuals. In reality, it is difficult for a farmer to get a specific identification of the causal agent and so the initial, symptomatic identification is used most often. This identification is made more accurate through the experience and knowledge of the farmer or extension officer. Experience may inform a farmer that the poor state of the crop is not a soil nutrient problem but is instead linked to recent weather conditions which favour the build up of a type of disease.

f. **Weeds** - these are unwanted plants that compete for the same environmental resources as the crop plant. Usually the weeds are better suited to the conditions and thrive to the real detriment of the crop. Some weed species are known to release toxic substances into the soil that retard plant growth (e.g. Black sage, *Cordia curassavica*).

Animal pests other than insects:

g. **Nematodes** - these are tiny worms, the biggest barely visible to the naked eye. They live in the soil and most species live on dead plant material. There are those, however, which live on living plant material, taking food and water and thereby reducing the vigour of the plant. Nematodes can also introduce pathogens into plants. Because these animals don't travel far on their own, their effect can be quite localised in a field. Patches of wilted or browning plants are usually an obvious symptom of nematode attack. ***Note:** man is very efficient at spreading this pest.*

h. **Birds** - they usually attack the seed, very young seedlings or the fruit and the damage can be immense. It is usually obvious when birds attack a crop. A point should be made here that also applies to weeds and nematodes. Some bird species are actually beneficial to the farmer. For example in the Philippines, ducks are released into rice fields to eat snail pests. Here the white cranes in the rice fields help by eating the Fall armyworm *(Spodoptera frugiperda).* For the plant species found in or around the crop, some will be weed species whilst others may have a beneficial role – providing a habitat for natural predators for example.

i. **Rodents** - mice and rats cause damage both in the field and in the storage bond. Red pea crops, grown on the Essequibo coast, sometimes suffer from rats. The rats enter the fields from neighbouring bush and eat the newly planted seeds.

j. **Slugs and snails** - they can be most damaging to seedlings in nurseries. The damage is normally done at night and is more likely during the wet seasons.

Experienced farmers and extension officers can, in most cases, identify which of the above causes are contributing to crop damage. At the very least, they should be able to recognise what it is about the crop that is not right. **This recognition of the symptoms is important and will help others pinpoint the causal agent, even if the farmer cannot.**

Identification is the first stage of a successful crop protection response and cannot be overemphasized. It is only with accurate information that successful action can be taken.

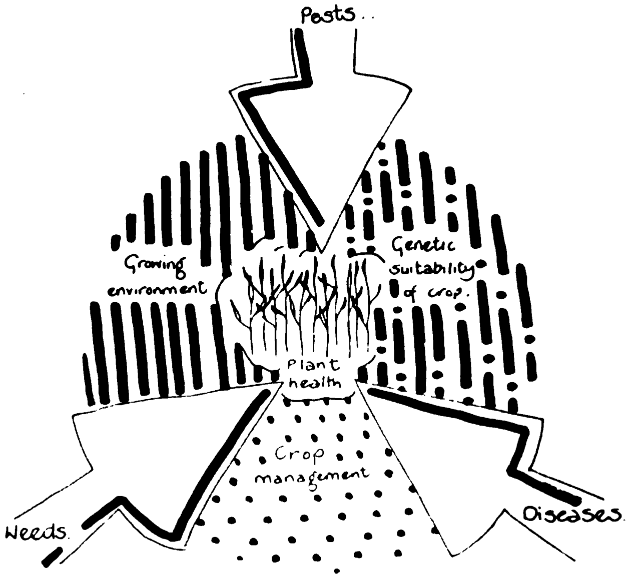
> What would you think if a doctor said, "Well, I haven't identified what's wrong with you but I'm going to operate anyway"!!

1.4 Gathering information. Factors regulating plant health and pest numbers

Successful management of crop protection activities requires access to accurate and relevant information. Information gathering is of the utmost importance. In terms of assessing the threat of a potential pest situation, or reacting to the presence of a pest, identification of the insect is only the starting point. The full assessment can only be made using available information on the pest, the crop and the surrounding environment. The more information we can obtain, the clearer the picture we will have of the pest/host situation. Using this we can make our decisions and initiate the appropriate control responses. As an initial step, it would be useful to find out about the **health of the crop** and **factors influencing the insect population** posing the threat.

Certain underlying factors relating to plant health can mask and complicate the process of identifying the agents causing crop damage. These factors also influence the susceptibility of the crop to the agent, which in turn affects the level of damage suffered. In Figure 1.2 the different influences on the health of a plant are diagrammatically represented.

Fig. 1.2 Influences on plant health



1.4.1 Plant health

The general health of the plant and the factors influencing it needs to be established when initiating a crop protection exercise. Everybody knows that if something is naturally weak or not looked after; it is more likely to suffer from any problem going around.

Poor plant nutrition leads to the plant being stressed. If it isn't getting the right nutrients or not enough water or is planted too close to other plants, for example, then it may succumb to a pest whereas healthy plants in the same area remain untroubled.

Plant health is affected by a number of things but the biggest underlying factor influencing plant health and the ability to stay healthy is **soil nutrition**.

Table 1.1 shows the main nutrients (elements) found in the soil, which are used for plant growth. Also given are the "hunger signs" which a plant may show when lacking that particular element. These hunger signs might mistakenly be identified as insect damage symptoms.

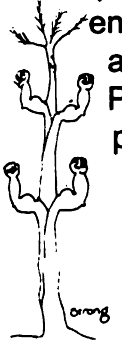


Table 1.1 - Plant nutrients, nutrient functions and symptoms of nutrient shortage

ELEMENT (symbol)	**FUNCTION**	**HUNGER SIGNS**
Nitrogen (N)	• general plant growth • protein production	1. pale green to light yellow leaves 2. drying up of leaves starting with lower ones 3. slow, stunted growth 4. reduced size of pods
Phosphorus (P)	• important to fast growing areas of the plant, (emerging leaves and root tips)	1. slender, weak stems 2. slow growth of plant 3. delayed maturity of beans 4. poor yields
Potassium (K)	• regulates food and water movements in plants • important resistance of pests and disease	1. mottling, curling and/or scorching of leaves starting with the older leaves 2. roots poorly developed, plants fall down 3. slow growth 4. pods spongy with decreased yields 5. poor fruit quality and appearance
Calcium (Ca)	• leafy vegetables require large amounts of Ca • used in cell walls & movement of sugars	1. leaf margins light green and/or wrinkled. Young leaves may remain folded 2. short roots with excessive branching 3. slow growth and poor yields

Note: Other mineral nutrients essential to plant growth include magnesium (Mg), sulphur (S), copper (Cu), manganese (Mn), iron (Fe), zinc (Zn), boron (B) and molybdenum (Mo). These are usually termed the micronutrients as the amounts required for healthy plant growth are small compared to those in Table 1.1.

Table 1.1 shows the role of major nutrients on plant health. If not present in adequate amounts they may directly cause reduced crop yields or may instead, through increased stress within the plant, lead to a greater susceptibility towards other problems such as adverse reaction to pest control activity (leaf burn, drop, etc.). An additional complication is that the stress, may not manifest itself outwardly, making its identification difficult.

As well as a soil nutrient deficiency, there are other causes leading to nutritional problems and these include excess fertilization or simply an imbalance in soil nutrients. Soil pH can affect availability of nutrients to plants. These situations can lead to plant stress.

So while the **problem** may be an insect, at a deeper level, the **cause** of the insect becoming a pest could be the **state** of the plant itself. Make sure the plant is not lacking in any nutrients. This might mean having a soil test done (which can be organised through the Ministry of Agriculture), and perhaps the application of appropriate fertilizers.

1.4.2. **Factors affecting insect numbers**

The size and dynamics of an insect population is affected by a number of influences that need to be understood if manipulation of that population is to be a success. Below is a list of some of these influences:

- Food resources
  - availability of host plant
  - health of host plant
  - stage of host plant development
  - availability of alternative host plants
- Biological mortality factors
  - predators (e.g. birds, other insects)
  - parasites (e.g. other insects, nematodes)
  - pathogens (e.g. viruses, bacteria)
- Physical environment
  - soil conditions (e.g. waterlogging, compaction)
  - weather conditions (e.g. direct sunlight, heavy rains)
- Farm management
  - crop choice
  - leaving fields to fallow
  - crop protection practices
  - keeping of livestock
  - rotation of crops
  - cultivation practices
  - farm hygiene
  - practices of neighbouring farmers

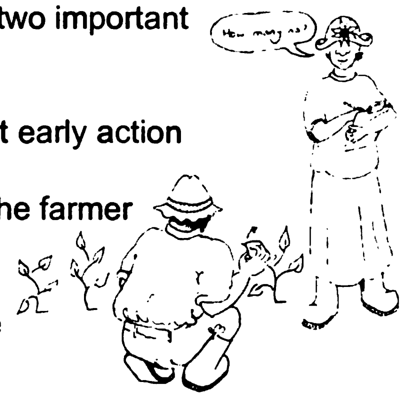
Monitoring is the way in which an insect population and the factors influencing it can be observed.

1.5 Monitoring of pest populations, their natural enemies and the environment

Monitoring the numbers and activity of insects provides the information to make quick, informed decisions concerning pest management activities. Monitoring has two important roles:

i. to give early warning of the presence of pest species so that early action can be taken;
ii. to evaluate on-going crop protection strategies. This allows the farmer to react to developments in the field by modifying his actions.

Monitoring is something a farmer does naturally. To be effective the following must be observed:



- it should be done regularly with the frequency increased at times of crop vulnerability;
- it should be an organised exercise. See below for some practical examples. Case #4 on Diamondback moth in Chapter 6 gives one method of scouting;
- the findings should be recorded for future comparisons and analysis; and
- the information should be used in crop protection decisions.

1.5.1 **Sampling for insect pests**

Sampling is a method of data collection that is more formal in structure than simple field observations. It relies on accurately examining part of an area so that observations on the whole of the area can be made. Take for example the sampling of an insect pest species within a crop. Because it would be impossible to investigate every plant in the crop, counting of the insects is restricted to defined subsections of the crop. From these counts it is possible to provide an estimate of pest numbers within the whole of the crop. If this exercise is repeated then additional information on **pest population fluctuations** is generated.

The objective of sampling is to obtain an unbiased estimate of a population. The assessment can be linked to insect numbers (to give such information such as *animals per unit area* or *per unit habitat*) or can relate instead to their activity or products. In this case such things as plant damage, insect droppings (frass), nests and old skins are recorded.

There are various sampling techniques and all are affected by certain conditions. Decisions concerning these conditions need to be made before the sampling activity is initiated.

> **Sample size** - the number of samples taken will influence the precision of the final estimate. The size can be increased by increasing the number of samples taken or by increasing the size of the individual sample areas. Obtaining increases in sample size often requires greater inputs in terms of time, personnel or money.
>
> **Sample patterns** - the choice of sampling pattern will affect the accuracy of the exercise. This choice is influenced by such things as sample area characteristics, pest species distribution, and organisational and resource capacity of the sampling team.

i. Random sampling is a sampling selection based on chance; all units in the target population have an equal, known chance of being selected. Throwing a (1m x 1m) quadrat into a crop represents this type of sample pattern.
ii. Stratified random sampling is a selection where the sample area is divided into a number of equal sized subdivisions or strata and sampling is done randomly in each stratum. This method is useful if the area to be sampled has distinct subgroups (e.g. in a mixed-crop situation) although care must be taken when defining the subdivisions to prevent introduced bias.
iii. Systematic sampling is where measurements are taken at fixed intervals in space or time so that the sample as a whole is spread more evenly over the population.

Timing of sampling is related to:
i. the life cycle of the insect. On occasions specific life stages are targeted for sampling. This could be because certain life stages are easier to sample than others or perhaps because the sampling of a particular life stage gives more useful information for crop protection purposes. The seasonality of insect populations should also be considered when timing the sample exercise.
ii. the time of day. Insects behave differently during different times of the day. Don't look for them in the midday sun if they have all hidden deep in the soil to escape the fierce heat. They'll probably be more active very early in the morning or in the evening cool. It is useful to know the habits of the pest insects during the course of a day or even during different climatic changes.

Some Methods of Collecting Insects in the Field

- **Traps** - light traps
    - pitfall trap
    - fly traps (use of a bait)
    - traps based on colour attraction
    - use of attractive plants as traps
- **Insect net** - sweep foliage of the crop
    - catch the insect "on the wing"

(see Chapter 6, Case #5 for design of net)

- **Beating umbrella** (where the plant is shaken and the insects are collected below in the "umbrella")
- **Aspirator** or "Pooter" where small insects can be sucked into a container without harm.
- **Sifting** of crop trash and leaf litter

Timing of monitoring exercises is crucial to maximizing the chances of a successful control program. There is no point in initiating a sampling exercise after the population explosion has occurred. Ideally results from monitoring should be available in time to forecast problems and allow time for remedial actions to be taken.

In some countries, farmers employ specialists to routinely visit and walk through their fields. Amongst other things, they inform the farmer of potential pest problems and give him an assessment of possible control strategies. The specialists' trade is information and they work hard at improving the knowledge they have. If a farmer can save thousands of dollars on a pest problem by pre-empting it, based on the information given to him, then the information itself must be worth a lot.

Knowledge is power and profits. Knowledge is by no means the exclusive right of anybody. **Make a point of accumulating as much relevant information as possible so that you are in a position to act effectively in your own interest.** During monitoring exercises, aim to obtain the following information concerning:

Before control activity

- **Crop health**
- **Pest numbers**
- **Non-target organism numbers**
- **Environmental conditions**
- **Insect biology and behaviour**
- **Available control options**
- **Costs**

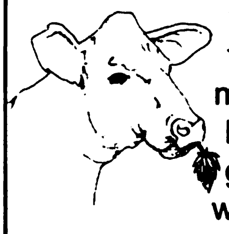
After control activity

- **Crop health**
- **Pest numbers**
- **Non-target organism numbers**
- **Environmental effects**
- **General benefits/problems**

1.6 Damage thresholds and economic injury level thresholds

1.6.1 Setting thresholds

What is a pest? Here we introduce the concepts behind the designation of pest status and the actions that are then subsequently taken. We can use an everyday example of cows wandering into somebody's yard. The most important concept illustrated below is our setting of thresholds that direct the actions we take.



Suppose a couple of cows enter your yard and start eating your grass. You don't really mind - the grass was long anyway and you could use their manure on your flowers. Also the weather has been dry, so the cows aren't sinking into the mud, leaving deep hoof-prints for you to stumble into later. However what happens when a further 10 cows enter the yard? Terrible! There's not enough grass for 12 cows and because of that, they're now starting on your prize-winning flowers and vegetables. The mess they're making is unbelievable - you'll have to get somebody to clear it away soon. In this situation, 2 cows are fine, providing you with some benefits, but 12, no way.

Now what action do you take? It depends on the number of cows. 2 cows, well you'd leave them, they're not a problem. 3 or 4 cows? They would cause a little damage but then it's not so bad that you have get up and disturb your lunch. On the other hand if it were 5 or 6 cows in the yard, you would chase them away. They are doing quite a bit of damage and it's worth the effort. When it comes to 12 cows you wouldn't even think about it. You would remove them, almost at any cost.

An extra twist to this is that if it was raining, the dangerous and unsightly hoof prints make even 2 cows too much. This reduction in the number of the cows (2) you were originally willing to have in your yard now has more to do with the present vulnerability of your environment than the specific number and presence of the cows.

This is a crude analogy for the concept of thresholds and the factors that influence them. Relating this to the insects in your field, there is a point where a rising insect population starts inflicting actual damage to your crop (i.e. at the "3 cow" level). This level can be termed the **damage threshold**. From this point their activity in your field will mean you are losing money. However, at and just above this threshold, the loss in money is less than the money you would have to spend if you initiated a control activity (i.e. at the "3-4 cow" level).

As the insect population increases, there is a level where, not only are the insect numbers detrimental to the crop, but that the damage which they are causing is costing more than it would take to attempt control of the pests using available resources. In our case this was at the "5-6 cow" level. This level has been termed the **economic injury level**. At this point it would be economically justifiable to initiate a control response. The concept of thresholds is graphically represented in Figure 1.3. It is worth noting here that it is almost impossible to get rid of every insect pest in a field and moreover, there is no need to kill all of them. Actually, having a few around is quite useful - food for natural predators for example.

Variations in thresholds relate to factors such as plant health status, crop type, stage of plant growth and all the factors that influence pest numbers. The setting of thresholds will largely depend on the information you get out of your monitoring program. Regular sampling and field observations will inform you of insect numbers, insect biology and their activity within the crop plants. Only through obtaining this information will accurate thresholds be set. Knowledge of the damage previous pest populations have achieved will help you decide what the present levels of pests are capable of doing now and at a future date. Remember crop and environmental conditions will always influence your final predictions and decisions.

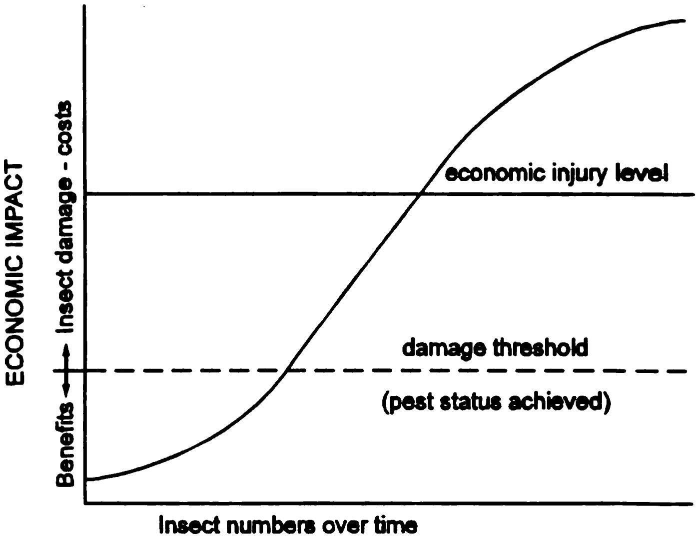


Figure 1.3: A graphical representation of population thresholds as they relate to the economic impact of a rising insect population

1.6.2 Biology of pests as it relates to thresholds

Knowing the biology of the pest when setting thresholds can cut out unhelpful and costly human bias. For example (going back to our cows), to those who don't know, 2 cows would seem to spell out disaster for the yard. These huge lumbering beasts, ripping up grass with their huge mouths, look as if they could do or are doing irreparable damage. If you don't study the actual effect of two cows in the yard, and just react to their large, obvious presence, you would probably take action and waste a great deal of time and effort removing them. In reality they were not harming your yard, just cutting the grass a bit. It's the same for insects, they may be in your crop, they may look bad, but if they're not at levels that lead to **actual damage**, then spending time and money controlling them is a waste.

Establishing proper thresholds requires a sound knowledge of the biology and behaviour of the insect. Aphids ("bloodfly") and leafminers ("chinese writing") are good cases in point. Both these insects are easily recognised, quite common and they look damaging.

Aphids settle on new growth and quickly grow in numbers. These tiny insects are recognised as a dark mass of bodies, coating the stems and the underside of leaves. The honeydew they produce encourages sooty mould - that ugly, black coating you often find on leaves and branches. Aphids are also protected by ants, which feed on the sweet honeydew. Honeydew is excess sap from the plant, which the aphids cannot utilise and so excrete. The ants, depending on the species, can be a nuisance to the farmer. If the aphids are not transmitting a viral disease, which they sometimes do, then their effect on yield is usually not great. This is especially true of permanent crops like citrus. In most cases, the slight lowering of yield does not warrant any expensive control measure. The only time to be careful is when the aphids attack seedlings or specific plant parts that represent yield such as the new, developing, green pods of red peas. In this instance they can leave stunted pods which don't grow to full size.

Biological control of aphids

Often the reason for aphid population explosions relates to inappropriate insecticide use, where the chemical has killed the different predators and parasites, which normally keep aphid populations in check. Aphid reproduction is rapid and this means that aphids will always re-establish themselves before their predators and parasites. Because of this, the aphid population grows to even higher levels within the field after the inappropriate use of an insecticide, sometimes to levels where the predators and parasites will never be in a position to bring aphid numbers down again to manageable levels.

Aphids are small, soft-bodied and usually slow moving. They are thus preyed on by a vast range of insects and other predators, and are parasitised by an equally large number of wasp parasites. In Guyana, it is common to see adult ladybird beetles and their larvae hunting and eating aphids (Plates 1.1 & 1.2). Also commonly seen are the colorful, semi-transparent, slug-like, syrphid fly larvae (Plates 1.3 & 1.4). These are a good example of something looking bad but actually doing some good. Aphids are parasitised by small wasps that lay eggs in their soft bodies. The wasps are difficult to see, but swollen brown aphid corpses are evidence of their activity. Natural control is enhanced by control of the ants that feed on the honeydew. Without these ants, there is no protection for aphids against predators and parasites. Sticky bands or insecticide bands around the base of the plants, work well against these ants.

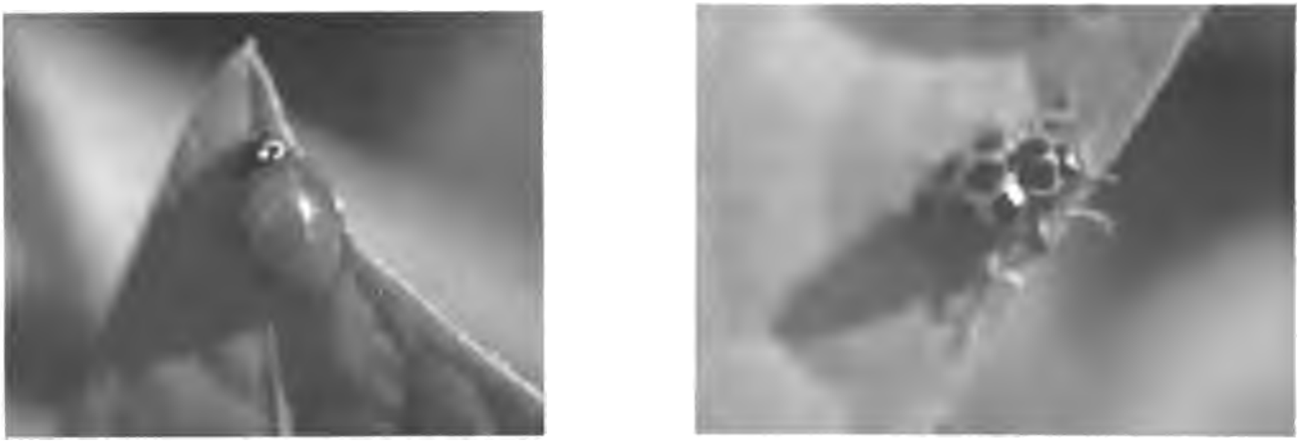
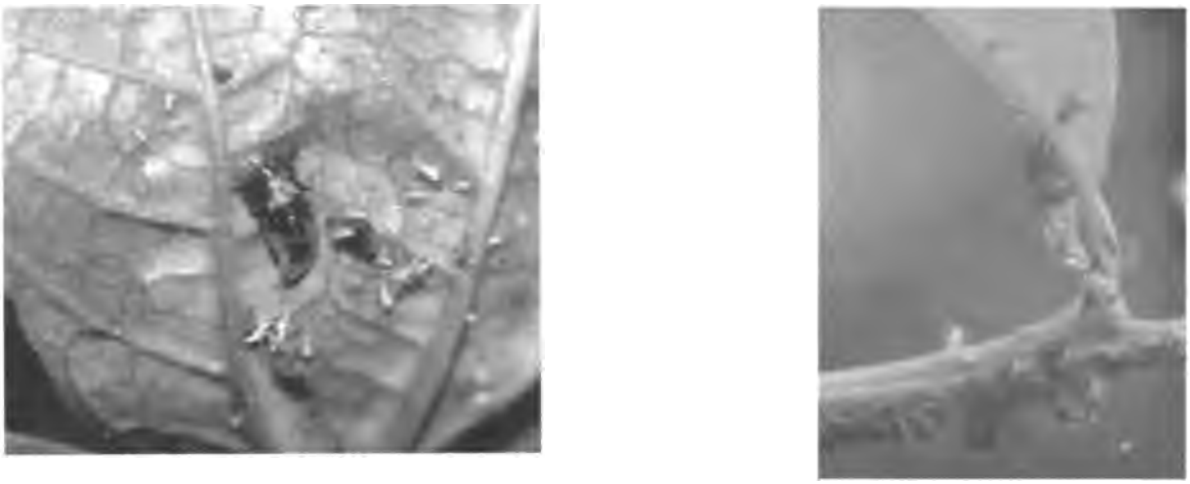


Plate 1.1 & 1.2 Two ladybird beetle species - these are effective predators of many insect pests



Plates 1.3 & 1.4 Syrphid fly larvae feeding on aphids

Low levels of aphids, under control from natural agents, can be left alone. If you didn't know, and just reacted to the mess they make, you would have set a low threshold against them (i.e. at the "one or two cow" level), and then acted. In such a case think of all the insecticides and man-hours you would have wasted.

In contrast to insect pests like aphids, there are insects that are not easily seen; monitoring these insects is helped by the use of traps. Weevils of palm and banana spend most of their lives out of sight. Therefore when you see one or two of them, they should not be ignored - there are, most likely, many more hiding in the plant. In this case we want a low threshold; we've only seen one or two and we're taking action. This is because one or two represents a damaging population level within the crop - the one's we have seen are the tip of the iceberg. Another instance where a low threshold is set is when the presence of only a few pest insects is enough to cause significant crop losses. Just one "worm" in a sapodilla is enough to make it unsaleable as a fresh fruit.

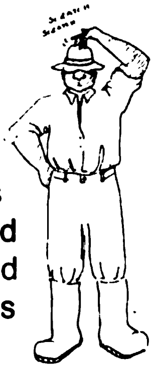
REMEMBER....

- Establishing damage thresholds is crucial to your final control decision. Knowing the biology of the pest is crucial to the establishment of these thresholds. (The behaviour of two cows is different from what it first appears).
- Observe carefully what actually occurs when damage is inflicted in a crop. Fallen or damaged fruit often attract hundreds of different insects but it is unlikely that any of them caused the initial damage, a bird was probably the culprit. There would thus be little point in controlling those insects found around the fallen fruit.
- Take time to examine your crop, identify what insects are there and what they are doing there. If you are not sure about an insect, take a specimen to the agricultural services for identification. They will let you know if it is an insect that you need to be concerned about. Ministry of Agriculture and other agricultural organisations will also advise you on the best monitoring technique for your crop and pests. They could also give you an idea of the threshold levels for some crops. You might have to adjust the thresholds to suit your needs.

Thresholds are set by:

- *knowing the biology and behaviour of the insect*
- *recognising and remembering the damage inflicted by the pest*
- *accurate monitoring results*
- *knowing the cost of the available control options*
- *knowing the economic value of the crop*

1.7 Decision making in pest management



Before a crop protection exercise is initiated, a decision on what needs to be done and when, is made. The quality of the decision is closely linked to the success of the control activity. To optimise the chance of success, it is useful to understand the different elements that make up the decision. A simple decision model is found in Figure 1.4 At each stage of the decision-making process there are requirements for access to information and a need for individual analysis and judgement.

1.7.1 How decisions are made

To divide the decision-making process in bite-sized chunks is in one sense artificial – all possible, imaginable factors play a role in affecting the decision. The exercise is useful, however, because it does help us to understand the main themes of the process and thus assist improving the process as a whole.

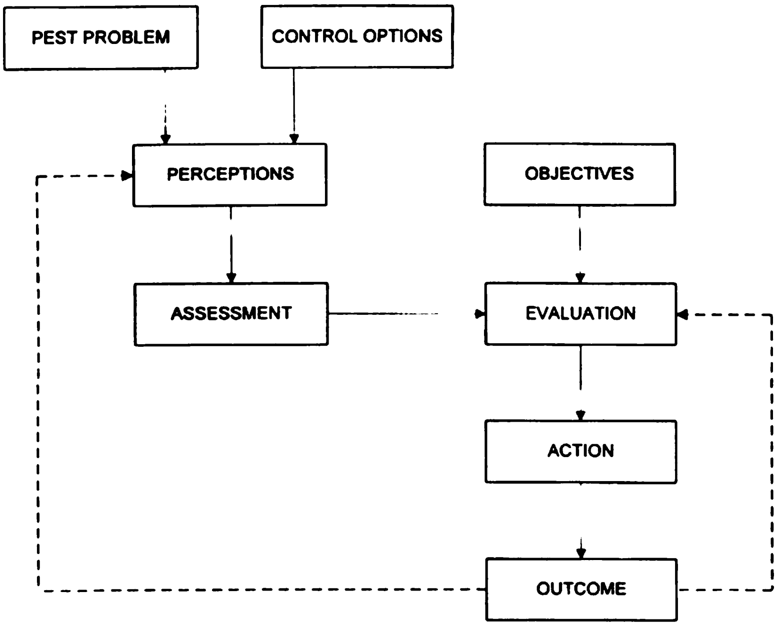


Figure 1.4: **Basic decision model**

The Problem: The pest and its activity in the field are the origin of a pest management decision. The mere threat of it is enough to begin the decision-making process.

The Options: The control options available to the farmer, (including the option not to act), give the choices that need to be considered. There may be constraints on the number of choices to be considered. This could be because of a lack of suitable application equipment on a farm, or because of the pesticide restrictions imposed by government regulatory agencies, for example.

The Perceptions: The reality of the problem and control options is filtered through the perceptions of the decision-maker. One hundred insects in a field may signify a disaster to one person (perhaps they had a bad experience with these insects the previous year), but not to another. The decision-maker's perceptions are formed by sources such as: direct experience with a pest or control technique; association with other pest management situations; agrochemical advertising; and advisory programs. More personal sources are also important.

Assessment: Here the decision-maker determines how each control option can be expected to perform in relation to the perceived pest problem. The assessments are not precise because it is impossible to know the exact outcome of a particular control option until after the event. At this level of the decision-making process, one assessment is not considered any better than another.

Objectives: This is what the farmer hopes to achieve through his crop protection activity. All control options will be judged with reference to these objectives. They are determined by the decision-maker's own personal value judgements – his emphasis may be on effectiveness and environmental safety for example. Others may not. Decisions can only be judged as being "good" or "bad" in relation to the objectives of the decision-maker. Traditionally these have been based on profit maximization, though fundamentally there exists the aim of preventing catastrophic losses. Usually there are a number of objectives and they are normally organised in a hierarchy of personal significance.

Evaluation: This is a crucial stage. Here it is determined how well each of the options, based on individual assessment, meets the decision-maker's objectives. This process can be simple if the objectives are themselves simple and if the perceived problem and control options are quite narrowly defined. This is not normally the case.

Action: The chosen control option is implemented at this stage.

Outcome: An action may give the most favourable outcome over the range of conditions expected and be, therefore, a "good" decision. If however the prevailing conditions are outside the expected range, the result of the control action may then be worse than expected. In this case we must differentiate here between a "bad" outcome and a "bad" decision. The decision may have been "good" (i.e. under normal conditions would have provided the most favourable results), but unfortunately the outcome was "bad". Differentiating between "good/bad" decisions and "good/bad" outcomes is important when an assessment is made of the decision making process.

1.7.2 How can decisions be improved

Decisions are based on two factors, information and choice. We can improve the decision making process by providing better information, by maximising our number of choices and by improving our ability to make the choice.

Improve the quality of pest management information by:

- ensuring it is more accessible (or more available);
- ensuring it is more specific to the problem/options;
- ensuring it is more reliable; and
- having it available earlier for use in the decision making process.

Maximising our number of choices largely depends on the information we have on the pest problem and the control options. It is also a matter of acknowledging all the control options/ strategies that are available to us. As mentioned earlier their will probably be external restrictions on the number of choices we have.

Improving our ability to make choices depends largely on our understanding of the pest problems and control options. This understanding can be improved by basic education on pest management principles, and by learning to present the problem in a complete and logical form, (by listing the options and their expected benefits and costs for example). This will make it easier to make a "good" decision.

The characteristics of your final decision will, in the end, depend on what information you have, how complex your objectives are and how much time you have to study the information and make the final decision. Your decision will lie somewhere between being a very methodical (even computer-assisted) one and a spontaneous one, more reliant on hunches and intuition.

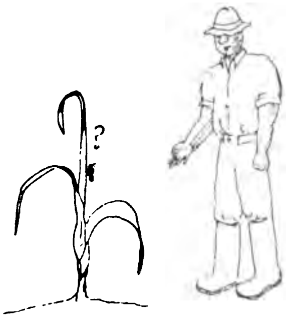
How important are these following influences?

money
security
job satisfaction
relaxation
religion
friends
health
environment
success
children
power
risks

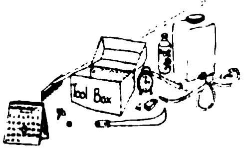
For an extension officer and farmer it is very important to try to discover the factors that influence the farmer's decision-making. Not only in technical terms but also at a more personal level. The decision-making process is heavily influenced by a person's individual bias. Understanding this will determine how successfully the extension officer and the farmer interact to develop the farming system.

1.8 Control options

"how should I control this insect problem?"



It is important that we recognise the range of control options available to us when developing a pest control response. In this section are listed some of these options. They are divided up into related groups.



When planning an activity try to use some of the control options in combination. Insect pests find it difficult to overcome a multidirectional control regime, (termed "horizontal" control). Relying on one option alone ("vertical" control), even if it is something like a strong insecticide, has its risks. The more barriers you throw up in front of the pest, the harder the pest will find it to overcome your efforts. Many of the options listed, operate as preventative measures and can be incorporated into a general farm management program. As a general recommendation keeping a farm clean is invaluable in keeping pest numbers down. As well as regular weeding this includes practices such removing and burning crop residues that may harbor pests.

1.8.1 **Cultural control**

This refers to a broad range of agricultural practices that impact on pest populations.

A. **Crop rotation** is the sequential planting of botanically unrelated crop plants for the purpose of maintaining soil fertility and soil structure. The fact that these practices are also beneficial to pest control through their suppression of pest numbers has been largely incidental.

Most insects show a preference to certain families of plants. *Crop rotation is most effective on pests which have a narrow plant host range and limited mobility.* If you have a pest that only likes one crop type and you then change to another crop type, that pest cannot survive. Try and alternate the plant families from which you choose your crops, especially if it is a piece of land which is continually cropped. Since eggs and pupae can survive in soil for longer than one crop, it is wise to make a rotation last over 3 - 4 crop cycles. In Table 1.2, some plant families and their constituent crops are given. Also included is the classification, according to Fukuoka (1985), of the families' natural resistance to pests and diseases. In this classification the following categories are given: High Resistance, (requiring no pesticides), Moderate Resistance, (requiring little pesticides), and Low Resistance, (requiring pesticides). This is something to consider when choosing a crop type.

Table 1.2 - Selected plant families with domesticated crop members, indicating level of natural resistance to pests and diseases.

CROP FAMILIES

Legume Family, (Leguminoseae)
moderate resistance
Black-eyed beans
Red peas
Peanuts
Bora

Tomato Family, (Solanaceae)
low resistance
Tomatoes
Boulanger
Peppers
Irish potato

Grass Family, (Graminaceae)
moderate resistance
Rice
Antelope Grass
Corn
Sugar Cane

Cucumber Family, (Cucurbitaceae)
low resistance
Cucumber
Pumpkin
Squash
Watermelon

Cabbage Family, (Cruciferaceae)
moderate resistance
Cabbage
Pak choi

These plant families (Table 1.2) may also be categorised in terms of their utilisation of soil nutrients, (e.g. the tomato family are termed **heavy takers** whilst legumes are **heavy givers**).

Changing the general farm environment will keep the pests guessing and not give them a chance to increase in numbers. Leaving an area fallow is also useful, especially if it is kept clear of weeds which play host to the insect pests.

B. **Soil cultivation** disturbs the habitat of soil-living pests and can expose them to dangers such as the desiccating effects of the sun, or the scavenging of predators; watch bird activity following a tractor and plough!

C. **Time of sowing and other manipulations in the timing of crop activities** can be very important. Many insects' life cycles are linked to weather patterns or other events during the year and so it is important to ensure that the vulnerable stage of the crop doesn't coincide with the cyclical emergence and development of the insect pest. If an insect always eats your planting material in August (because that's when the pest occurs in high numbers), then try planting in July or September.

Large scale monoculture systems, (such as rice farming) where the planting of the crop occurs at different times in the season, will lead to a steady build up of pests over time. An important way of reducing this pest build up is for everybody to plant his or her crop at the same time (block sowing). There are periods in a crop cycle where a crop is unsuitable for the pest's existence. If planting over an area is synchronous, then these unsuitable stages in the crop cycle will be present across the whole farming area. Thus, if there are no other host plants in the area, the pest has no alternative but to leave or die. This has been well documented in the rice cultivation of South-east Asian countries.

Other important cultural practices

- Fertilizer management
- Changing planting dates
- Timing of harvest
- Mixing crop varieties
- Crop rotation
- Repellent crops
- Over-planting and varying seed rate
- Selective weeding
- Intercropping
- Use of resistant varieties
- Water management
- Trap crops
- Using clean planting material

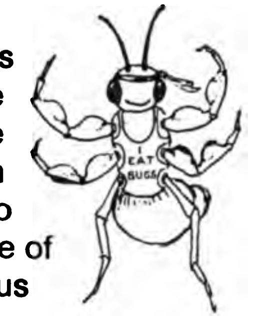
1.8.2 Mechanical and physical control

This refers primarily to situations where some physical factor in the environment may be modified to prevent or minimise a pest problem. This may be as simple as manually wiping the white, wooly mealybug ("blight"), off your houseplants, with a damp sponge.

Important mechanical and physical practices

- Destroying ants nests
- Painting stems with sticky materials, lime etc
- Removal of infested plants
- Selective pruning
- Row covers
- Repellent crops
- Over-planting and varying seed rate
- Scarecrows, sound devices
- Hand picking
- Wrapping of fruits
- Trapping
- Application of materials, (ash, smoke, salt etc.)
- Burning vegetation

1.8.3 Biological control



Biological control can be defined as the use of natural enemies to suppress pest species. It refers principally to parasites and predators but may include disease organisms. It always involves some degree of deliberate manipulation that distinguishes it from natural control. **Innoculation** involves the introduction of new species of biological control agents into areas where they did not previously occur. An example of this is the use of the ladybird beetle and wasp species released against the Pink Hibiscus Mealybug in Guyana and other countries across the Caribbean. **Mass rearing and release** is directed at boosting numbers of indigenous control agents. **Conservation and encouragement** aim to make better use of natural enemies that already exist in an area. This for the most part, involves minimising harmful effects resulting from the use of insecticides.

1.8.4 Chemical control

Insecticides offer the most effective way of killing insects. Relatively small amounts of the chemical kill large numbers of the insect pest. Of primary importance to the farmer or agricultural worker is the choice of insecticide. The agrochemical industry has a large number of other products, e.g.

Herbicides, ("weedicides") - kills unwanted plants
Fungicides - kills or prevents fungal infections
Nematicides - kills nematodes
Rodenticides - kills rats and mice
Fertilizers - replenishes soil nutrients
Ripeners - speeds up the process of fruit ripening
Defoliants - destroys foliage when required
Flowering stimulants - improves flower production and hence seed production.

Just because an agrochemical product comes in a company packet and has a chemical smell doesn't mean that it can be used for any agrochemical function - obvious, isn't it? Well, quite often, people use fungicides to treat insect problems, possibly because of a misidentification of the problem or through insufficient knowledge of the control product. Unfortunately, this is like taking a table tennis bat to face the bowling of Curtly Ambrose or taking a Brian Lara 501 cricket bat to a local table tennis competition. Nearly right, but still a million miles away.

It is very, very important to read and understand the labels on agrochemical containers, not only to take the right safety precautions but also to make sure you have the right product and that you are using it correctly.

Below are a few examples of some of the common insecticides, fungicides and herbicides found in Guyana:

Insecticides	**Herbicides**	**Fungicides**
Actellic (Pirimiphos-methyl)	Dual	Captan
Agree (Bt bacteria)	2-4-D	Cuprosan
Ambush (Permethrin)	Gramoxone, Millquat	Fuji-One
Basudin (Diazinon)	Roundup, Touchdown	Kitazin
Danitol (Fenpropathrin)		Kocide
Dipel, MVP (Bt bacteria)		Manseb
Fastac, Pestac (Alpha cypermethrin)		Benlate
Karate (Lambda cyhalothrin)		Dithane
Malathion (Malathion)		
Mirex, (Mirex)		
Nuvacron, Azodrin (Monocrotophos)		
Pegasus (Diafenthiuron)		
Sevin (Carbaryl)		
Vydate L (Oxamyl)		

Please refer to **Appendix 1**, which has a more complete list of insecticides, found in Guyana.

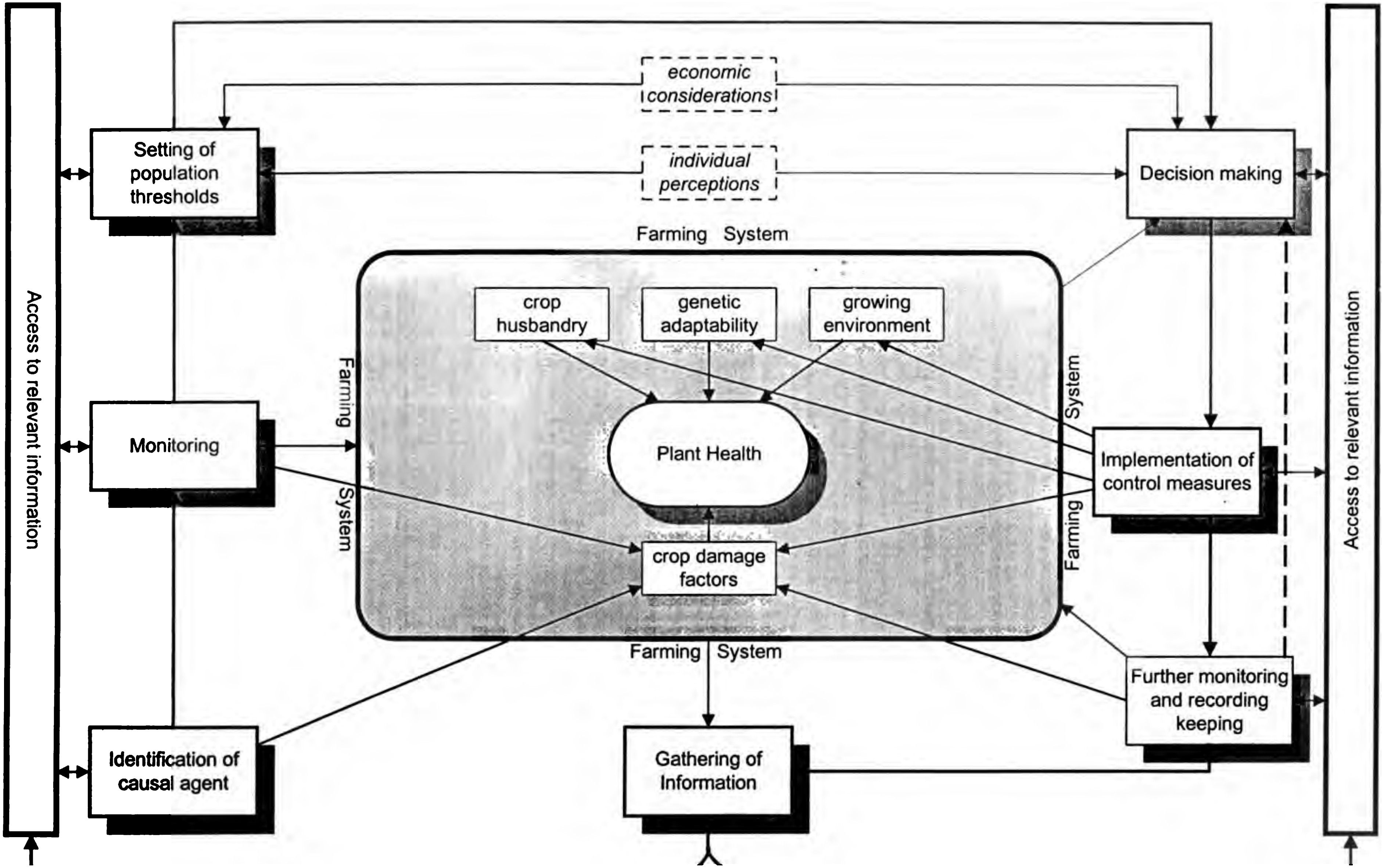
At first glance there appears to be a huge number of insecticides to chose from but on closer inspection only a few fit your farming system, budget and particular pest problem.

1.9 Assessment, continued monitoring and record keeping

The assessment of the control exercise will largely depend on how close the results match up to the objectives set for the exercise. Others may judge the exercise differently due to their differing objectives. Whatever the assessment, all aspects of the exercise should be recorded, including objectives set and results achieved, so that future control exercises can build on this experience. Monitoring and assessment should not just be restricted to the period after the control activity. Make sure that these activities occur throughout the control exercise so that the results or observations that come from this are available for ongoing decisions.

An organised record keeping system will enable you to interpret and build on your control exercise. Without it you will find it hard to remember everything learnt or seen and in a sense, when the next pest problem comes around, you will be back to where you started. Record keeping may be as simple as keeping a farm diary or may be as complicated as buying a computer with all the latest software.

Figure 1.5 Interaction of the 7 IPM components, plant health and associated factors



1.10 Conclusions

Figure 1.5 shows how the 7 components of IPM interact within a farming system. The diagram highlights the many levels at which the components impact onto the various elements of the farming system. The diagram also characterises IPM as a process and this needs to be emphasised. Many people already have a fair idea of the variety in control options available to them and are aware of the various benefits derived from some of the IPM activities. What needs to be understood however is how best these IPM components can be brought together to produce an effective and compatible pest management system. This sort of "systems approach" encourages a greater awareness that will not only be more likely to achieve long term pest control successes but that will also benefit the general management of the farm.

Each of the 7 IPM components needs to be represented in a control activity irrespective of how much time can be afforded to the protection of the crop. Why monitor if you are not going to use the information in determining thresholds or in making decisions? How could you go about collecting the right information if you have not identified what is causing the damage in the first place?

Integrated Pest Management is more of a concept than a set of strict recommendations. What this book hopes to do is encourage a change in the way a person approaches a pest problem. The book is not meant to contain every piece of information needed to implement an IPM activity. Ideally the book will prompt a fresh look at what constitutes a correct response to a pest problem.

Things will not change overnight after the adoption of IPM principles. Programs that give quick, spectacular results are often short-lived or have high hidden costs. Gathering the necessary information and developing an understanding of how it all relates to your situation takes time. Working through the information and advice given to you by others also takes time. Some will be useful to your efforts whilst some will not. You are the best person to decide this.

You may not feel comfortable adopting these "IPM concepts". They might not seem to have the security or basic effectiveness of your present chemical control strategy. Well, try incorporating some of the IPM activities into your existing program - monitoring; threshold setting; correct identification of the pest; improving crop nutrition for example. After that you may feel more comfortable investigating the use of some others, such as the use of alternative control options.

The continuing chapters follow the general themes of IPM introduced in this chapter. This book cannot and does not cover all aspects of IPM. Below is a quick outline of what is covered.

Chapter 2 introduces some of the major insect pests of Guyana. The information in this chapter will help in the identification of an insect problem. It also offers some information on pest biology and on methods of control.

Chapter 3 gives some practical information on pesticides and their use. **Chapter 4** concentrates on management and safety of pesticides. Attention is paid to their use in IPM programs.

Chapter 5 discusses the potential role of plants and plant products in crop protection and lists 21 local plants that could play a useful role here in Guyana. Assistance to those wishing to investigate local plant properties for themselves is also given in this chapter.

Chapter 6 looks in detail at five common pest problems here in Guyana. The control of these pests is discussed and specifically looks at possible use of IPM techniques. Each study emphasises certain aspects fundamental to IPM.

It may be questioned why two chapters have been dedicated to pesticides. The present reliance on agrochemicals in Guyana necessitates that we find a responsible role for pesticides in pest management. Just because one of the objectives of this book is to rationalise and reduce the use of pesticides there is no justification that we should ignore them or not help dry and improve their use.

We hope that you find this book interesting and of some practical value.

CHAPTER 2 SOME SERIOUS INSECT PESTS OF CROPS IN GUYANA

2.1 Introduction

Large numbers of insects are found on the earth and they make up the most numerous group of animals. The majority of insects are quite beneficial to man. They play important roles which include, cross-pollinating plants, feeding on dead plants and animals to recycle nutrients, aerating the soil, and providing us with a range of useful products, (honey, silk, dyes, etc). Insects also have an aesthetic beauty and are utilised in many ways so that man can appreciate them.

Only a small percentage of insects are pests of crops. However, the damage that is caused is often quite serious. Several factors are important in deciding how serious a pest is. These include the nature of the damage caused, the number of insects causing the damage and the value that is placed on the damage.

Specialists divide insects into groups. Features such as structure of the wings, mouthparts, types of development and many others are used to place them into taxonomic categories. The names of some of these categories are given in Chapter 1. Some of the most abundant kinds of insects include moths and butterflies (Lepidoptera), beetles and weevils (Coleoptera), ants, bees and wasps (Hymenoptera). These important insect groups are introducted below.

2.2 Key pest groups, their damage and control

Table 2.1 lists the names of some of the most serious pests of crops in Guyana. These have been selected primarily from Duodu (1993). Lepidoptera, Hemiptera and Coleoptera contain many of the important crop pests.

2.2.1 Butterflies and moths (Lepidoptera)

Butterflies and moths can be recognised by the tiny scales on their bodies, wings and by their mouthparts, which consist of a coiled tube, used for sucking liquid food. Moths tend to be active at night and hold their wings out flat, while butterflies are active daytime and hold their wings straight up.

Caterpillars are the young of this group. Generally, the caterpillars represent the most damaging part of the life cycle. They feed heavily on many plants and damage the young plant, growing points of plants (buds), leaves, stems, flowers and fruits. Farmers suffer heavy economic loss when the plant is damaged in these ways. Seedlings have to be replanted, heavily damaged plants produce lower yields and the quality of the final product, whether it is a leafy vegetable, e.g. pak choi, a fruit, e.g. tomato, etc. is reduced. Lowered yields combined with reduced quality can be devastating economically.

Table 2.1 - Some serious insect crop pests found in Guyana

Scientific Name	Common Name	Crops Attacked	Damage
LEPIDOPTERA			
Agrotis spp.	Cutworms	Corn, tomato, cowpea, cruciferous vegetables	Larvae cut seedling
Brassolis sophorae	Coconut Caterpillar	Coconuts	Larvae feed on leaves
Corcyra cephalonica	Rice Moth	Stored rice	Larvae feed on grain
Diaphania hyalinata	Melonworm; Pickleworm	Cucurbits	Larvae feed on leaves and flowers; bore into fruits; flowers shed
Erinnyis ello	Cassava Hornworm	Cassava	Larvae feed on leaves
Helicoverpa spp.		Bora, cowpea	Larvae damage leaves and bores pods
Helicoverpa zea	Tomato Fruitworm	Tomato	Larvae feed on leaves and fruits
Heliothis virescens	Pigeon Pea Borer	Pigeon pea	Larvae bore pods
Hellula phidilealis	Cabbage Budworm	Cruciferous vegetables	Larvae bore growing points
Keiferia lycopersicella	Tomato Pinworm	Tomato, boulanger	Larvae damage fruits and leaves
Maruca testulalis	Legume Pod Borer	Bora, cowpea, pigeon pea	
Mocis latipes	Grasslooper	Rice, sugar cane	Larvae defoliate plant
Plutella xylostella	Diamondback Moth	Cruciferous vegetables	Larvae feed on leaves
Sitotroga cerealella	Angoumois Grain Moth	Stored paddy, maize	Larvae feed in grain
Spodoptera frugiperda	Fall Armyworm	Maize, rice, sugar cane	Larvae feed on leaves
Symmetrischema capsica	Pepper Bud Moth	Chilli and Sweet peppers	Larvae attack flowers
HOMOPTERA			
Aphis craccicvora	Groundnut Aphid	Bora, cowpea, peanut	Suck sap
Bemisia tabaci	Whiteflies	Tomato, sweet potato, cassava, boulanger, cowpea, tobacco & others	Transmit virus; associated with sooty mould
Dialeurodes citrifolii	Citrus Whitefly	Citrus	Suck sap; leaf and fruit fall; associated with sooty mould.
Dysmicoccus brevipes	Pineapple Mealybug	Pineapple	Transmit wilt and gummosis
Eriococcus tucurincae		Chilli and sweet pepper	Suck sap; produce honey dew; associated with sooty mould
Maconellicoccus hirsutus	Pink Hibiscus Mealybug	Wide host range, (ornamentals mostly)	Suck sap; distort leaves
Toxoptera citricida	Brown Citrus Aphid	Citrus	Suck sap; young leaves distorted; vector of Tristeza Virus; transmit wilt and gummosis
Whiteflies, (unspecified)	Whiteflies	Chilli and sweet peppers	Suck sap
ISOPTERA			
Nasutitermes costalis	Termites	Avocado, coffee, sugar cane, mango	Nest on plants; feed on coffee roots; attack planted cane setts

Table 2.1 (cont'd.) - Some serious insect crop pests found in Guyana

Scientific Name	Common Name	Crops Attacked	Damage
THYSANOPTERA			
Thrips palmi	Thrips	Boulanger	Suck sap
COLEOPTERA			
Alcidion deletum	Egg Plant Stem Borer	Boulanger	Larvae bores stem
Callosobruchus maculatus	Spotted Cowpea Bruchid	Legume seeds	Feed internally on grain
Cosmopolites sordidus	Banana Weevil	Plantains and bananas	Larvae bore corm
Cylas formicarius	Sweet Potato Weevil	Sweet potato	Bore tuber
Epitrix spp.	Flea Beetle	Boulanger	Eat holes in leaves
Hypothenemus hampei	Coffee Berry Borer	Coffee	Adults bore berries
Rhizopertha dominica	Lesser Grain Borer	Paddy, milled rice	Feed internally on grain
Rhynchophorus palmarum	South American Palm Weevil	Coconut	Larvae tunnel palm; adults transmit red ring nematode
Sitophilus oryzae	Rice Weevil	Paddy, milled rice	Feed internally on grain
Strategus spp.	Cockle	Coconut	Adults bore into young palms
ORTHOPTERA			
Gryllotalpa spp.	Mole Crickets	Bora, cowpea, maize	Cut seedlings
Scapteriscus spp.	Mole Crickets	Maize	Cut seedlings
Unspecified species	Crickets	Bora, cowpea, cruciferous vegetables, cucurbits, maize, peanuts, tomato	Cut seedlings
HYMENOPTERA			
Acromyrmex spp.	Leaf-cutting or Acoushi Ants	Most crop species	Cut leaves
Atta spp.	Leaf-cutting or Acoushi Ants	Most crop species	Cut leaves
Bephrata maculicollis	Soursop Wasp	Soursop	Attack seeds and fruits; larvae develop in seeds and leave exit holes on fruit
Solenopsis spp.	Pineapple Ants	Pineapple	Tend mealybugs on pineapple
HEMIPTERA			
Corythaica cyathicollis	Eggplant Lacewing Bug	Boulanger	Suck sap; leaves yellow
Corythaica monacha	Eggplant Lacewing Bug	Boulanger	Suck sap; leaves yellow
Oebalus poecilus	Paddy Bug; Ghandi	Rice	Suck sap from grain
DIPTERA			
Hydrellia deonieri	Rice Leafminer	Rice	Larvae mine leaves
Liriomyza trifolii	Leafminer	Bora, cowpea	Larvae mine leaves

A. Some control strategies against Lepidoptera

(i) **Crop sanitation**: Remaining parts of crop can provide sustenance for a new generation of pests. When these are destroyed, perhaps by fire, juvenile stages of the insect are killed. This helps in the control of, for example, the coconut caterpillar.

(ii) **Ploughing/forking**: This allows juvenile stages of especially Cutworms to be brought to the surface, where they are exposed to sunlight which can cause them to die for lack of water or be prey for predators, such as ants and birds.

(iii) **Hand-picking**: Where plants are small and caterpillars are large, e.g. Cassava Hornworm, these may be picked out if the field is small.

(iv) **Flooding**: In the case of rice, Armyworm and Grasshoppers can be controlled by submerging the plants for 24-48 hours. Caterpillars drown and do not move from one field to another.

(v) **Crop rotation**: The main idea behind this strategy is not to cultivate the plant on which the pest feeds. This provides a forced break in the insect's life cycle and pest numbers are thus reduced. It is advisable to use plants from different families to derive the maximum benefit from rotations.

(vi) **Viruses**: Several types of viruses, which cause disease in caterpillars, have been commercialised. They are known to give a good level of control in crops. An important advantage is that they are highly specific and do not kill beneficial insects.

(vii) **Bacteria**: Some types of bacteria, e.g. *Bacillus thuringiensis* (Bt) produce a toxin that is specific to Lepidoptera. This allows natural enemies to be preserved so that they can continue their job of reducing the pest population further. Commercial preparations of Bt are available.

(viii) **Insecticides**: A number of insecticides are effective against caterpillars. These include *carbaryl, chlorpyrifos, cypermethrin, fenitrothion, malathion, triazophos,* and *permethrin*. This list is not exhaustive. They must always be used according to manufacturer's instructions. Since many factors govern the use of a given pesticide, advice must be sought from competent sources.

2.2.2 Aphids, whiteflies, scale insects, mealybugs (Homoptera)

Members of this group can be recognised by their beak, which consists of four piercing needle-like structures. The beak arises from the back of the head and is used to pierce plants and to aid the sucking of sap. It is often necessary to use a hand lens or microscope to recognise these structures. There is great variation in body form. In the winged forms, wings at rest are held roof-like over the body. Their life history involves both sexual and asexual reproduction.

All Homoptera are plant feeders and some of them are serious pests. Aphids, white flies, and mealybugs secrete a sweet substance called honeydew on which many ants feed. This sticky substance also forms food for the multiplication of a black fungus called Sooty Mould. On many plants, e.g. citrus and peppers, the leaves may be coloured black, because of the sooty mould and this interferes with light reaching the cells of the green leaf. If this blockage is serious, leaves manufacture a reduced amount of food and hence the plant produces less which results in a lowered plant yield. Withdrawal of the sap by these insects also deprives the plant of manufactured food. The homopteran pests are also involved in the transmission of plant diseases, e.g. Tristeza virus and gummosis.

B. Some control strategies against Homoptera

(i) **Pruning**: Cutting off heavily infested parts of a plant reduces the pest population immediately and provides fewer parents for the next generation. The plant itself can become a lot more vigorous since food reserves are now shared between fewer branches. This technique is particularly applicable to citrus infested with whiteflies, aphids and scale insects. It has become an important strategy in the fight against the newly introduced Pink mealybug.

(ii) **Burning**: Having pruned the plant of infested parts, it is essential to get rid of them safely, since they contain insects that can move on to clean plants. Burning is an excellent method.

(iii) **Hygiene**: Clothing, implements and equipment can harbour small populations of some homopterans. It is important to wash these before going into uninfested areas.

(iv) **Use of clean planting materials**: Many homopterans are not vigorous movers, e.g. mealybugs and scale insects. However, they can be spread when infested cuttings are planted. Proper inspections can reveal infestations very quickly.

(v) **Reducing protection afforded by ants**: Many kinds of ants are associated with aphid and mealybugs and perhaps offer some protection to them. If the ants can be controlled chemically by spray-banding tree trunks or use of sticky bands, then the pests might become more vulnerable to a range of other insect predators and parasites, such as ladybird beetles and wasps. This technique of denying ants access to plants has been shown to give enhanced results when ladybird beetles have been used against some homopterans.

(vi) **Soap water application**: Aphids and whiteflies are very delicate insects and are easily killed off in heavy rains. To avoid this, many of them are found hiding underneath leaves. Applications of soapy water sprays are helpful in dislodging and killing some of them. This technique is well used by gardeners in ornamental plants, such as hibiscus and crotons.

(vii) **Chemical control**: Many pesticides are available for killing aphids. These include *chlorpyrifos, cypermethrin, diazinon, dimethoate, triazophos* and *fenitrothion*. As always, manufacturers' recommendations must be followed strictly. However, chemical control of mealybugs and scales is not very effective because a waxy layer covers them. Sometimes the mealybug and scale problem can become greater after repeated sprays because broad-spectrum insecticides have killed off their natural enemies. Systemic insecticides such as *dimethoate* are often used but seldom are control levels satisfactory.

2.2.3 Beetles and weevils (Coleoptera)

Beetles and weevils are the largest insect group and its members are highly variable in size and habits. They can be recognised by their hardened forewings, which meet in a straight line down the middle of the insect when the wings are at rest. The hindwings are not thickened and are folded underneath the forewings during resting.

Jaws are well developed and are capable of biting through wood, seeds and incredibly, lead pipes at times. This group has biting and chewing mouthparts. Those that are plant feeders are capable of boring into tough stems, coffee berries, tubers, corms and leaves. Many are important storage pests of grains, (rice, beans, wheat, maize, etc.) and tubers.

C. Some control strategies against Coleoptera

Unlike moths and butterflies, many of these insects are pests both as adults and young. Strategies to control them can be quite varied.

(i) **Crop rotation**: This is sometimes possible, sweet potato cultivation can be changed after 2-3 crops to provide a break in the life cycle of Sweet potato weevils helping in their control. Fallowing may also be used when it is known that the area is heavily infested.

(ii) **Crop sanitation**: It is critical to remove the breeding materials for beetles and weevils if their numbers are to be kept at manageable levels. When bananas are harvested, for instance, the remaining pseudostems should be chopped up, dried and burnt so that the Banana weevils do not have an assured food supply. This strategy is equally applicable to sweet potato for Sweet potato weevil control, and boulanger for Stemborer.

(iii) **Insecticide-treated traps**: Often it is possible to treat attractive plant food for Coleopteran pests with an appropriate insecticide. Consider for example, the Coconut palm weevil that tunnels into the trunk. Pieces of trunk are treated and distributed around the trees and as the insects feed, they are killed. Alternatively, the traps are not treated and the insects are hand picked from the bait. Papaw stems have been used as traps. This technique can be used against Banana root weevil, by using pieces of banana stem.

(iv) **Chemical control**: Many insecticides are useful against beetles and weevils. *malathion, fenitrothion, dimethoate,* and *triazophos* are examples, but this list is by no means exhaustive. A large number are available from pesticide companies and recommendations must be followed strictly. Planting material such as sweet potato slips may be soaked and plants may be sprayed, e.g. against Flea beetle. In the case of storage pests such as Lesser grain borer and all others, fumigation using toxic gas is recommended but a trained technician must do this.

(v) **Miscellaneous control strategies against storage pests**: Grains especially can be frozen for a prolonged period say about 15-18 days to kill off insect infestation. Alternatively, they can be refrigerated. Below 10°C, storage insects do not multiply, In the case of seed grains they may be admixed with recommended pesticides. Disinfested grain can be stored in airtight containers.

2.3 Representative pests from insect orders

2.3.1 **Tomato pinworm - *Keiferia lycopersicella* (Lepidoptera)** (Plate 2.22)

Crops attacked: Boulanger and tomato.

Life cycle: The female moth lays oval eggs on any part of the plant but usually chooses the underside of leaves perhaps to protect against drying out or against attack from predators. Depending on conditions the eggs hatch from between a few days to a week into light orange larvae. The mature caterpillar is purplish-black and is around 6-8 mm in length. The resting or pupa stage may be found between leaves, in the soil or in exceptional cases in the fruit. Adults are small grey moths of about 6 mm in length and they emerge three to six weeks after eggs are laid. The insect is known to multiply many times per year under tropical conditions.

Damage: Newly hatched caterpillars feed in different ways on the plant; they mine leaves, feed on the upper or lower surfaces of the leaves or roll the leaf and feed in a protective shelter. They are also known to bring two leaves together and feed within. When infestations are heavy, leaves become dry and drop off depriving the plant of its capacity to make food and hence lower yields. Occasionally the larva can penetrate the fruit through the fruit stalk.

Control: Monitoring of infestation on plants is an important guide to making pest control decisions. Under Florida conditions economic thresholds have been determined. When there are more than three larval feeding areas on three tomato leaves on a plot of 160m^2, control was deemed necessary to prevent economic damage. The sampling plan used in this instance was to examine the three top leaves with four or more leaflets of two plants. The pest may be controlled by products such *as Bt, cypermethrin, permethrin, deltamethrin, carbaryl, fenvalerate* and a number of others. Always follow manufacturers instructions on their use. Techniques such as crop sanitation, and ploughing also reduce residual populations of insects.

2.3.2 **Fall armyworm - *Spodoptera frugiperda* (Lepidoptera)** (Plate 2.5)

Crops attacked: Rice, sugar cane, maize, sorghum

Life cycle: The female moth lays eggs numbering one hundred or more, in clusters on the host plants. Greyish-brown scales from the abdomen of the female cover the eggs. Sometimes eggs are laid on non-host plants, grasses and on fences and buildings. Hatching takes place between 5-6 days after egg laying. Newly hatched caterpillars crawl up to highest points on host-plants and can be disseminated to other plants from there. Caterpillars feed for about two weeks after which the resting stage is reached. Pupation may take place in the soil or between leaves that have been spun together. About 7-9 days later, adult moths emerge.

Colouration in the larvae is variable and may change from light green or brown to nearly black. Some light and dark lines are found along the length of the caterpillar and many warts are found on the segments. The fully-grown caterpillar can be identified by the yellowish 'Y' on the head. In the adult female moth, forewings are greyish brown with dark and light markings while those of the male are brownish with a light grey area near the tip.

Damage: In rice newly emerged caterpillars are only able to feed on the underside of leaves towards the tip, producing a 'burnt' appearance of the tips. As they get older they are able to defoliate the crop and cause severe reduction in yields. Usually there is only one generation per season in rice. However when there are more, plants close to maturity are attacked. When white cranes are seen in rice fields one is almost certain that caterpillars are there.

Sugar cane leaves are also stripped by this caterpillar. But attack is limited to canes less than six weeks old. In severely attacked cane, the young plant may be killed necessitating replanting. Defoliation also takes place in corn and sorghum and in the case of corn, the ear may be attacked.

Control: Flooding for 24-48 hours in rice can control caterpillars; the insects die by drowning. Weedy fields harbour residual populations of the pest, from which attacks can be launched on the crop. Good weed control is therefore essential. In the rice industry pesticides such as *trichlorphon, carbaryl* and *fenitrothion* have been used to gain satisfactory levels of control. *Cypermethrin, deltamethrin* and *permethrin* are also effective. As in previous examples, this list is not exhaustive, and advice on suitable available insecticides must be obtained from competent sources. The sugar industry has a policy of using insecticides only when it is absolutely necessary, and pursues the development of Integrated Pest Management programmes. *Malathion, lambda-cyhalothrin* and *chlorpyrifos* have been used in their pest management program.

2.3.3 **South American palm weevil - *Rhynchophorus palmarum* (Coleoptera)** (Plate 2.15)

Crops attacked: Coconuts, oil palm.

Life cycle: The account given here is taken primarily from Hill and Waller (1990b). The female weevil lays between 200-500 eggs in the numerous shelters present in the crown of the palm but may sometimes seek out branches which have been cut as egg-laying sites. Newly hatched larvae called grubs are yellowish white, legless and oval, with a rust-coloured head. When mature they measure 5-6 cm long. The grub stage lasts between 2-4 months. Pupation occurs in a special sac called a cocoon under the bark. The resting stage lasts for about 14-28 days. Adults emerge and begin to feed within their holes before coming out. The adult weevil varies in size but can be between 4-5 cm long and has the characteristic snout and hardened forewings of weevils.

Damage: The grubs are heavy feeders; they bore into the upper trunk with their biting and chewing mouth parts, making long tunnels as they feed. Damaged tissues soon rot and there is a distinct, unpleasant odour. If the damage is extensive, the palms may die or the crown may break off in high winds as a result of being weakened by tunneling. At the early stages of attack, the outermost branches turn yellow and then die and this progresses to the innermost leaves. Under Guyanese conditions, mainly the young palm 2-5 years old are attacked. The weevil is known to be a carrier of a nematode that causes a serious disease of coconuts known as Red ring.

Control: It is not easy to detect the attack during the initial stages. However holes in the plants from which chewed fibres and thick brownish liquid oozes are indications of attack. Pieces of papaw stems and split coconut trunk have been used as traps to lure the weevils, which are collected daily and killed. Alternatively the split trunks of about 1m length can also be soaked with a broad-spectrum insecticide and spread out in different parts of the field. Adult weevils are attracted to these decaying trunks and are killed when they come into contact with them.

The egg-laying female actively searches for injury on the palm to deposit her eggs. Therefore injury caused by machines or cutlass should be avoided. Injuries to the trunk may be tarred to make them less attractive as egg laying sites. In cases where palms are severely damaged, it is best to cut and burn them so as to reduce the available breeding grounds. Good farm sanitation also helps to eliminate other breeding grounds. *Cabaryl* when sprayed on to the trunks and injected into infested tunnels has given satisfactory levels of controls for the juvenile stages. Other injected insecticides include *demeton-s-methyl* and *oxy demeton-methyl.*

2.3.4 **Pink mealybug - *Maconellicoccus hirsutus* (Homoptera)** (Plate 2.23)

Crops attacked: This insect is also known as the Hibiscus mealybug because it damages many of the plants in this family. Ornamentals, shade trees and fruit trees, are among the 125 plant species it can attack. This is a new pest in Guyana; it was only detected early in 1997.

Life cycle: Mani (1989) in a review discussed the life cycle, which had been determined by workers in India. Development from egg to adult may take between 23-35 days, with each female laying a maximum of over 650 eggs. There are multiple generations in a year. Oval, smooth, orange eggs of 0.3-0.4 mm in length are laid in a cottony sac. Within 3-9 days, hatching is complete. Newly hatched mealybugs are called crawlers or nymphs and these are able to distribute themselves on the host. Juvenile stages may last between 10-25 days after which both adult males and females are produced. Adults are small, varying between 2.5-3 mm in length. Multiplication can take place without participation by the male.

Damage: Mani (1989) reports a wide range of plants that are attacked. These include crops such as mango, pomegranate, sugar apple, peanut, pigeon pea, sugar cane, dunks, sorrel, guava, coffee, citrus etc. Here in the Caribbean and in Guyana recently, the pest attacks a range of vegetable, fruit and tree crops, ornamentals and forest species as well as weeds.

Young and adult insects have piercing and sucking mouthparts. They feed on tender parts of plants and inject toxic saliva. As a result of feeding and toxic saliva, young shoots become twisted, curled, pleated and crinkled. Flowers and fruits and leaves, which are attacked heavily, drop and the plants may die. In the later stages of infestation, a white fluffy or cottony mass is found on the plant parts. The insects are found below this white material.

Mealybug attack has resulted in severe economic losses. Plant yields are reduced, crop production costs increase because of costly control programmes and markets for crops such as pineapples and other fruits have been lost to Caribbean islands because of trade restrictions. Under Grenadian conditions annual losses are estimated to be about 3.5 million U.S. dollars. Here in Guyana the losses have not yet been quantified but it is expected to be millions of U.S. dollars. The pest is considered to be perhaps the most potentially dangerous insect yet to come to Guyana and the Ministry of Agriculture along with the National Agricultural Research Institute, using inputs from other agencies, is working feverishly to contain the pest.

Control: Guyana has adopted a multi-pronged approach to control the Pink mealybug. These include:

1. Institutional framework

An order has been made under the Plant Protection Act of Guyana empowering the Chief Agricultural Officer to act to prevent the spread of the pest. Prior to this order being made, a broad-based technical Pink Mealybug Task Force has been sensitizing decision-makers about the threat posed by the Pink mealybug. Linkages have been made between the Inter-American Institute for Cooperation on Agriculture (IICA), the International Institute of Biological Control (IIBC - Trinidad) and the Caribbean Agricultural Research & Development Institute (CARDI), which have allowed for training of technicians, construction of insect-rearing facilities here, importation of beneficial insects and carrying out Pink mealybug surveys countrywide.

2. Biological control

Preliminary results in Grenada and Trinidad where the wasp *Anagyrus kamali* and ladybird predator, *Cryptolaemus montrouzieri* have been used as biocontrol agents, have shown reasonably good success. This wasp and ladybird have been known to control Pink mealybug in Egypt and India respectively. The wasp lays its eggs in the mealybug and their young consume the insect while completing their own development. The ladybird, on the other hand, feeds directly on the mealybug. Thousands of these wasps and ladybirds are now being imported and released on Pink mealybug-infested plants at different locations. On completion of the insectary, these insects will be mass-reared in Guyana for release.

3. Education and awareness

An important objective of the programme is to create public support for reporting infestations and support for control activities. Radio programmes, TV productions, video documentaries, posters, leaflets, public lectures, have all been used in pursuit of this education drive. A one-day Pink mealybug Seminar has been held to bring members of the public and key agricultural workers up to date on all aspects of the insect. Results are encouraging so far.

4. Insecticides

Field control of Pink mealybug by pesticides is usually difficult because the insect is covered with a waxy coating, tends to crawl into sheltered cracks and can re-invade crops from other sources nearby. In addition, many of its natural enemies are killed off and the insects can reach populations far greater than before. It is possible that systemic pesticides can overcome the problem of wax since the plant, on being sprayed, becomes toxic to the insects. Initial trials with the systemic insecticide *dimethoate* in Grenada has been estimated to give between 90-95% control of Pink mealybug, while *sevin* has given good control (90-95%) of ants tending Pink mealybug, (Pollard 1996). However, systemic pesticide use may kill off biocontrol agents. Insecticide trials have started using fresh produce. One line of investigation being pursued is to fumigate infested produce in sealed containers. Should this method kill off eggs, juveniles and adults at an economic dose without leaving residues above international limits, trading in fresh produce could begin.

5. Cultural control

At this time, the main effective cultural measure utilised is the cutting and burning of infected plants. At times this approach can be very painful, because prized plants have to be destroyed. Perhaps the habit of soliciting cut parts of ornamentals should be curtailed, since infected planting material can be carried from one region to another.

2.3.5 Termite - *Nasutitermes costalis* (Isoptera)

Plants attacked: Coffee, avocado, sugar-cane, mango and other fruit trees.

Life cycle: Termites live in colonies and have a well organised social structure. Different categories of termites, such as workers, soldiers, kings and queens all live in nests. Small cylindrical eggs are laid by the queen and upon hatching, the young, called nymphs, contain all the external characteristics found in adults, except wings. The nymph, as it grows, sheds its skin several times and becomes an adult. What kind of adult the nymph becomes is largely affected by the influence of the community. Harris (1971) recognises three ways in which new termite communities are formed:

(1) By pairs of flying termites;
(2) By development of substitute reproductive termites in an isolated part of an existing colony;
(3) By partial migration of a colony, leaving the rest of the colony to develop substitute reproductives.

Termite swarming is triggered to some extent by rains; its main function is to find new areas to infest. In the simplest case, mating between males and females takes place, the wings are shed, a nest site is selected, eggs are laid, and the colony develops.

Damage: This species is usually a minor pest, but within recent times, it has caused some concern in a few of the sugar estates. There is uncertainty about the precise species causing the damage, but this is being addressed by sending specimens to reputable international experts for identification.

Observations at Guyana Sugar Cooperation (GUYSUCO) indicate that all stages of growth of cane are attacked. Termites feed on young cane setts at the region where the cane is cut. As the cane grows, they build tell-tale channels on the rind, climb into the foliage, and penetrate the stalk. Canes damaged by breakages, rodent attack or stem borer, also provide access. Nests are found on the stalks or at the base of the canes. (Personal communication - B. Dasrat, GUYSUCO Agricultural Research Unit).

In the case of coffee, there is also some doubt as to the species causing the damage (Sinha, 1980). Nests are found on coffee trees and root damage has been observed. It is common to observe large nests on old coconut and mango trees and at times avocado. The main damage in trees is tunneling. In this type of feeding, woody tissue is removed and utilised by termites as food. If damage is severe, the trees become structurally weak and can collapse in high winds. In addition, the movement of food materials up and down the trunk is affected which then in turn affects yields.

Control: Within the affected sugar estates, a multi-faceted termite management program is being developed (Personal communication - B. Dasrat, GUYSUCO Agricultural Research Unit). Routine surveys are done to locate infestations. When these are found, the nests are collected in plastic bags, carried to a safe area away from canes and burnt. An insecticide, *pyrazole carbonitrile* (Trade Name, Fipronil) is then applied to stools. On fields that are ready for harvesting, surveys to determine levels of infestation are done. If these levels are between 8-10%, upon harvesting the fields are flooded for 24 hours. In fields which have greater than 10% infestation, harvesting is done early and is called 'sacrificial harvesting'. Where termites have damaged young canes, *etephon* and phosphate fertilizers are used to promote new shoot emergence.

In other crops affected, nests should be broken and burnt. For coffee, the nest at the root site can be broken up with a shovel, removed and burnt. Soil at the nesting site and around it may be drenched with a termiticide, such as *cypermethrin, permethrin* or *chlorpyrifos*. Follow instructions on label carefully.

Note carefully how each strategy that is used by GUYSUCO reduces the termite population and boosts plant growth. This approach has brought recent outbreaks under control on several estates.

2.3.6 **Whiteflies - *Bemisia tabaci* (Homoptera)**

Crops attacked: Cotton, tomato, tobacco, sweet potato, cassava, beans, boulanger, cowpea, are some of the crops on which this pest develops, but these are by no means the only crops. The insects also breed in a wide range of weeds. Whiteflies until recently were not considered pests of any economic significance, but their status has now changed and *Bemisia tabaci* in particular is now occurring as a major pest in several vegetable-growing areas of Guyana (Munroe, 1995a). We do not know for sure that the Silverleaf whitefly, *Bemisia argentifolii is* here as yet.

Life cycle: About 100 or more pear-shaped or elliptical eggs, each of about 0.2 mm, are laid mostly on the underside of leaves. Each egg is attached to the leaf by a short, hairlike filament. Eggs take about a week to hatch into nymphs, which begin to feed. On completion of their first change of skin or moult, they remain fixed to one place on the leaf and can be recognised as variable-coloured, pear-shaped, scale-like insects. By the end of the third change of skin, a so-called "pupa" or "puparium" stage is reached. The "pupa" is pear-shaped, flat, whitish to yellowish, is about 0.6-0.8 mm long and still resembles a soft scale, though less flat than the previous nymphal stage. At this stage, the eyes of the adult can be seen through the skin of the pupa. Nymphs take between 2-4 weeks to develop fully. Adults are about 1 mm long, have a yellowish body covered with a white waxy powder. Each has four broad-tipped wings and can be seen rising from infested plants that are shaken slightly. Reproduction may take place with or without the male.

Damage: Whiteflies have piercing and sucking mouthparts and therefore suck sap from plants, especially from the young leaves. Their feeding damage is usually minor. However, they are known to transmit viruses that cause disease in plants. These include Golden bean mosaic virus, Tomato yellow leaf curl virus ~~and~~ Tobacco leaf curl virus. In the case of tomato, severity of outbreak of disease is high when whitefly population is high. Honey dew is also secreted by whiteflies. This provides sustenance for sooty mould and reduces capacity of leaves to make food.

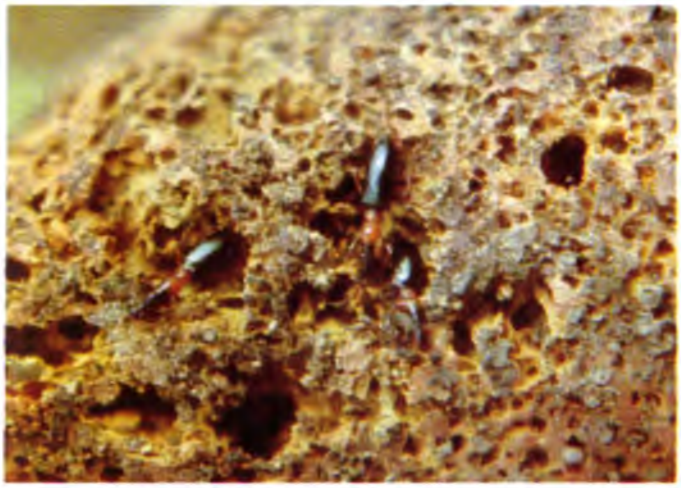


Plate 2.1 Adult Sweet potato weevil, *Cylas formicarius* on damaged tuber

Plate 2.2 Larva of Cutworm, *Agrotis* sp. on soil

Plate 2.3 Melonworm larva, *Diaphania hyalinata* on damaged leaf

Plate 2.4 Adult Paddy bug, *Oebalus poecilus* on rice

Plate 2.5 Larva of Armyworm *Spodoptera frugiperda* on rice

Plate 2.6 Cassava, Armyworm, *Erinnyis ello* on cassava

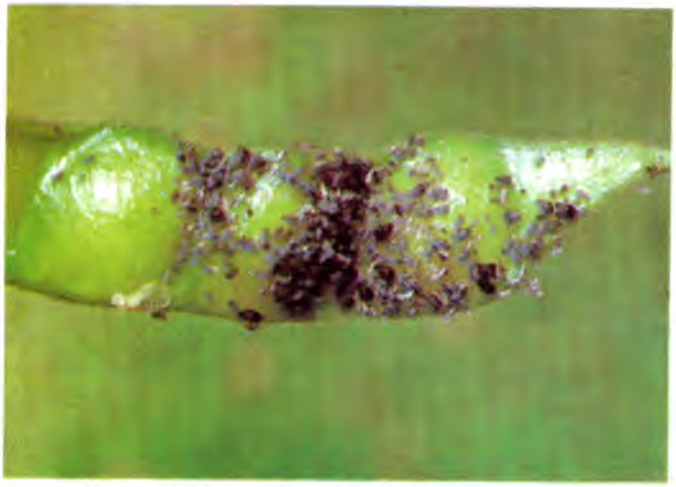


Plate 2.7 Colony of Aphid, *Aphis craccivora* on pigeon pea pod

Plate 2.8 Legume Pod borer, *Maruca testulalis* in pigeon pea pod

Plate 2.9 Pigeon pea borer larva, *Heliothis virescens* feeding on pigeon pea pod

Plate 2.10 Whitefly adults, *Bemisia tabaci* on cowpea leaf

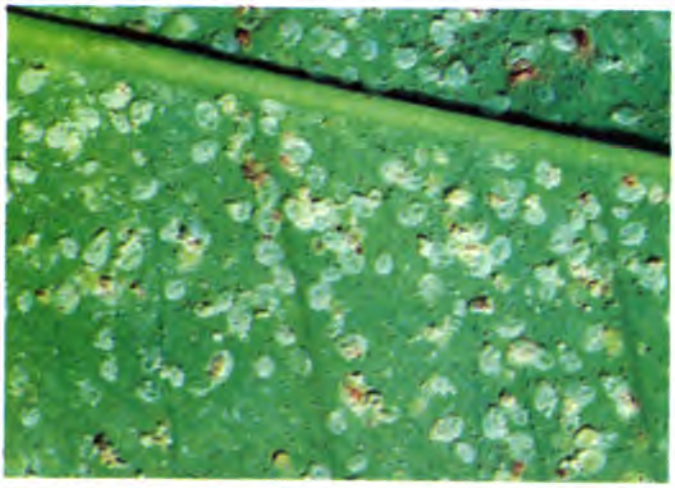


Plate 2.11 Mostly empty puparia of Citrus whitefly, *Dialeurodes citrifolii* on citrus leaf

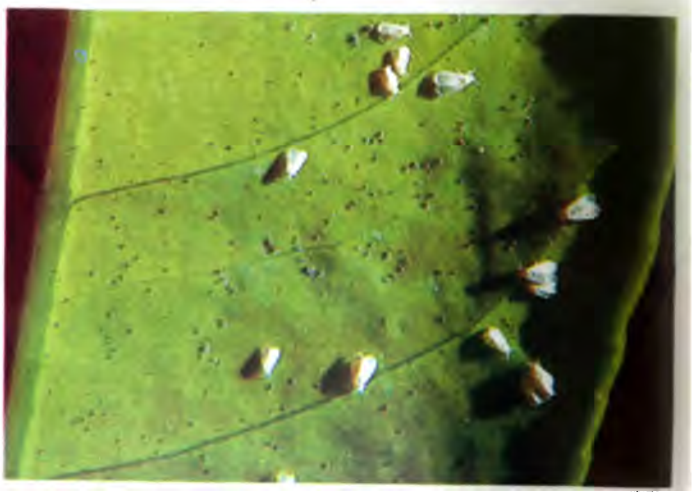


Plate 2.12 Egg-laying adults of Citrus whitefly, *Dialeurodes citrifolii*

Plate 2.13 Feeding damage of termites, *Nasutitermes costalis* on sugar cane

Plate 2.14 Bannana root weevil, *Cosmopolites sordidus* on damaged corm

Plate 2.15 South American Palm weevil adult, *Rhynchophorus palmarum*

Plate 2.16 Diamondback moth larva, *Plutella xylostella* on the under side of cabbage leaf

Plate 2.17 White Mango scale colony, *Aulacaspis tubercularis* on mango leaf

Plate 2.18 Coffee berries with holes made by Coffee berry borer, *Hypothenemus hampei*

Plate 2.19 Lacewing bug, *Corythaica cyathicollis* adults and damage caused on boulanger leaf

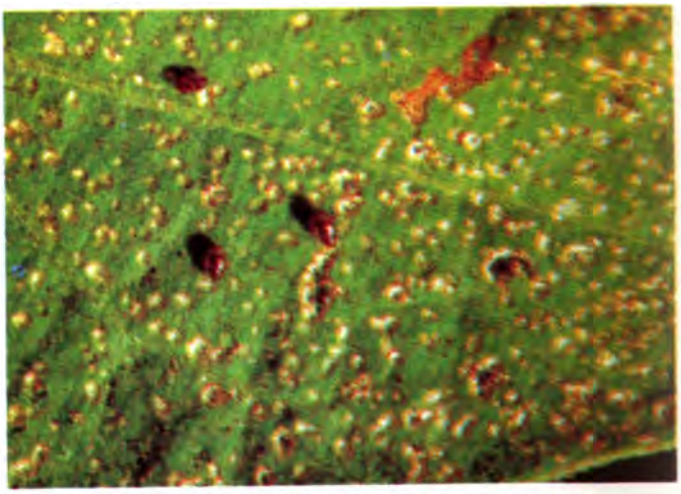


Plate 2.20 Adult Flea beetles, *Epitrix* sp. and damage on boulanger leaf

Plate 2.21 Boulanger leaf damaged by Thrips, *Thrips palmi*

Plate 2.22 Mine and larva of Tomato pinworm, *Keiferia lycopersicella* on tomato leaf

Plate 2.23 Pink mealybug, *Maconellicoccus hirsutus* damage on ochro

Plate 2.24 Green form of Tomato fruitworm, *Helicoverpa zea* on tomato

Control: Systemic or contact insecticides may be used. Sprays should be directed to the undersurface of leaves where the insects are usually found. *Dimethoate, cypermethrin, chlorpyrifos, azinphos-methyl, diazinon* and a number of other insecticides may be used. However, because of the problem of resistance to pesticides (Georghiou and Lagunes-Tejeda, 1991), this approach can be difficult and costly. Munroe (1995 b) points out a number of strategies that can be used in an integrated way for effective management of this pest: keep plots free of weeds since the pests can breed on these and then invade the crops; avoid having mature crop near newly-planted crop; experiment with a trap crop such as cucumber to protect tomato from damage; mulching with aluminium-coloured plastic attracts whiteflies which are killed by the high temperature once they land. Yellow sticky traps can be used to reduce population levels since the insects are attracted to this colour. STP, an additive to motor oil, may be used to coat cardboards (4 x 11") painted yellow on both sides (Meitzner and Price, 1996).

2.4 Summary

Several hundred insects are known to attack crops in Guyana. Some are considered major pests while others become pests only occasionally, and yet others are just incidental pests. In determining whether to control an insect or not, it is critical to identify the pest and its damage. We have identified some of the major ones in Guyana and have explained some general strategies that can be used for their control. The colour plates selected represent major pests of crops grown here. We hope that they can be useful for the recognition of pests. In a presentation of this length, it is not possible to examine in detail the full range of specific control measures for all the major pests. However, this chapter, with its general guidelines, followed by specific examples, will we hope be helpful to you in your fight against harmful crop pests.

CHAPTER 3 INSECTICIDES AND THEIR CORRECT USE

3.1 Introduction

The use of insecticides is still one of the most effective and cheapest ways to manage insect pests. Considering the IPM approach as described earlier, the use of insecticides is still one of the most important components of an IPM program. A grower should be in a position to make an informed decision as to when and what type of insecticide to use for the most compatible control approach.

Mode of action

Most insecticides act on **contact**, when an insect is sprayed with an insecticide or when it touches the dried insecticide residues. Some insecticides have to be eaten to be effective and are termed **stomach poisons**. **Systemic** insecticides are taken up by the plant and are translocated around to its different parts. This gives the plant "in-house" security.

To make an informed decision on what types of insecticides to use and how to use them, it is necessary to understand their characteristics. Today, there are many kinds of insecticides available, and many of them have their own special way of preventing crop damage from insects. Many of them kill only certain kinds of insects, and do so in a completely different way to most of the earlier insecticides. It is not within the scope of this manual to describe the characteristics of all of today's insecticides, although some are mentioned in various sections of this book. The grower is referred to the insecticide labels for detailed information on each insecticide. In addition, sales representatives and the extension service are important sources of information on insecticides and their use.

3.2 Insecticide formulations

When one wishes to use an insecticide, one goes to the pesticide dealer and purchases the material. This can often be a bewildering experience because of the great variety of names, types, formulations, etc. An understanding of formulations can help the end user to choose sensibly.

When pesticides (which include insecticides) are manufactured, the technical grade material is produced in a pure state that cannot be applied safely and cheaply. It is usually further processed to a usable form for dilution prior to application. During this processing, the pure compound or active ingredient is diluted to improve storage, handling, application and safety. The product is then called a formulation. There are over 35,000 formulations and the list is growing. However, nearly all can be placed in just over ten categories. The following are some of the more important types you are likely to encounter:

- **Sprays** (insecticides, herbicides, fungicides)

(a) Emulsifiable concentrate: These have the active ingredient (killing agent) mixed with a detergent-like material and oil. When added to water, a milky solution is formed. Such formulations are abbreviated **EC**.

(b) Water-miscible liquids: These can be mixed with water and are usually abbreviated **WSC, L, SC** or **S**.

(c) Wettable powders: These are concentrated dusts that can mix with water. They are abbreviated **WP**.

(d) Water-soluble powders: Such formulations dissolve in water and are abbreviated **SP**.

(e) Ultra low volume concentrates: These are applied without further dilution using special spray equipment. They are abbreviated **ULV**.

- **Dusts** (insecticides and fungicides)

  In this type, the active ingredient may or may not be diluted before application, e.g. sulphur dust.

- **Aerosols** (insecticides, disinfectants)

  In this type, the formulation is pressurized in special containers equipped with a push button for spraying.

- **Granules** (insecticides, herbicides)

  These are small pellets that incorporate the killing agent.

- **Fumigants**

  These are materials that have low boiling points and are often gases at room temperature. Usually gases are packaged in pressurized steel containers or specially made small tins.

- **Baits**

  In these formulations, the toxic material is mixed with an attractive food material for the pest. Baits could be used to kill rodents, insects, and snails and slugs.

- **Insect repellents**

  These could be aerosols or rub-ons.

- **Insect attractants**

  Sex lures such as pheromones are placed in this category. They are used especially in traps.

3.3 Classification of insecticides

Insecticides have been classified in several ways. Two of the methods that have gained prominence are discussed. The World Health Organisation has recommended that pesticides in general be categorised by the risk or hazard that they pose to the user on entering the body through the skin or mouth, be they solid or liquid. The hazard is measured in terms of the amount of pesticide that will kill 50% of a rat population or in terms of milligrams of pesticide per kg of rat body weight.

Five categories are recognised:

(1) **Ia** - Extremely hazardous
(2) **Ib** - Highly hazardous
(3) **II** - Moderately hazardous
(4) **III** - Slightly hazardous.
(5) **IV** - Unlikely to present acute hazard in normal use

Good labels of products in categories **Ia** and **Ib** usually bear a symbol such as skull and crossbones to draw attention to the risk. Often a word or phrase follows, such as Very Poisonous or Highly Toxic. Symptoms of poisoning, first aid and antidote if applicable (medical advice) are usually given on labels of pesticides in **Ia** and **Ib**.

The other classification system, used almost world-wide, is based on the chemical groups or classes to which the insecticides belong. Below are some of the more important groups you are likely to meet.

- **Organochlorines**: These were some of the first synthetic insecticides that were manufactured. They contain the elements carbon, chlorine and hydrogen. Sometimes they are given other names such as chlorinated hydrocarbons. The group is noted for its great persistence, accumulation of residues in fatty tissues of organisms and negative effects on the environment. As a result of these characteristics, many countries have banned or severely restricted their use. Examples of insecticides of this group include *chlordane*, *dieldrin*, *aldrin*, *endrin* and *DDT*.

- **Organophosphates**: This group of insecticides is made up of a very broad group consisting of all insecticides that contain the element phosphorus. They are generally more toxic than organochlorines but are non-persistent and do not accumulate in food chains. It is this latter quality of chemical instability that has brought them into agricultural use as substitutes for DDT. Some members of this group are highly toxic, e.g. *parathion*. Many are systemic (*dimethoate*, *dicrotophos*, *disulfotan*) and can be used by the home gardener. Systemic insecticides are especially toxic to sucking insects. Other examples of organophosphates include *monocrotophos*, *diazinon*, *malathion* and *pirimiphos methyl*.

- **Carbamates.** Carabmates are a group of insecticides that are derived from carbamic acid. *Carbaryl* was one of the first successful carbamates; it has low toxicity to mammals and control a broad spectrum of insects. Other members of this group such as *methomyl, aldicarb, oxamyl* and *carbofuran* can dissolve in water readily and are therefore plant systemics. They are somewhat similar to organophosphates in that they do not accumulate in fat tissues and break down rapidly in the environment.

- **Synthetic pyrethroids.** Historically, the natural pyrethrin insecticides have been obtained from the flowers of chrysanthemum. However, chemical detective work by many researchers led to the manufacture of pyrethrin-like materials which are referred to as synthetic pyrethroids. They are known for their high insecticidal activity and stability in sunlight. Examples include *allethrin, bioresmethrin, permethin, deltamethirin* and *phenothrin*.

- **Microbials.** This type of insecticide is obtained from micro-organisms. One of the best known is obtained from the bacteria *Bacillus thuringiensis*. Concentrates of the bacteria contain spores with a toxic protein which, when fed upon by caterpillars injure their guts. Another microbial called nuclear polyhedrosis virus is especially active against some types of caterpillars. Avermectins represent a rival class of closely related antibiotics with insecticidal properties amongst others and was first discovered in the soil organism *Streptomyces avermitilis*. Many microbials are under development and it is expected that the list will be a growing one.

- **Insect growth regulators (IGRs).** This is a relatively new group of chemical compounds that alter growth and development in insects and cause their death eventually. Included in this group are ecdysone (moulting hormone), juvenile hormone, juvenile hormone mimic and juvenile hormone analog. Insecticides based on hormones have the advantages of being effective against specific groups of insects, and being non-toxic to humans and other warm-blooded animals. For instance, *diflubenzuron* (Dimilin7), a compound related to IGRs exerts its action on larval stages of most insects by inhibiting or blocking the synthesis of chitin, a vital material making up the durable, hard outer covering of insects. *Kinoprene* (Eustar7) is effective against a range of insects such as aphids, whiteflies, mealy bugs and scales that attack ornamentals and vegetables. It is selective for Homoptera and causes a gradual reduction of population by inhibiting development, reducing egg-laying, killing eggs laid and sterilising mature whiteflies and aphids (Ware, 1983).

3.4 Application equipment

- **Lever-operated knapsack sprayers**

  This is one of the most widely used small sprayers. It consists of a tank which will stand upright and when in use fits comfortably on the back like a knapsack. It consists of a hand-operated pump, a pressure chamber and a lance with an on/off trigger and one or more nozzles. A model popular here, is made by Cooper Pegler Co. Ltd.

- **Compression sprayer**

In this sprayer, an air pump is used to pressurize the spray tank that is filled to just over two-thirds. They are popular on farms/households and in programmes for mosquito control.

- **Rotary sprayers**

Hand-held models have battery-powered motors which spin the disc(s). Drops of pesticide from a reservoir are spun out from the disc. Low volumes of liquid are used in these sprayers and are thus quite advantageous where there is difficulty in getting water and labour cost for application is high.

- **Power-operated hydraulic sprayers**

A variety of power-operated sprayers have been designed and start from small, hand-carried engine-driven pump units to large, self-propelled sprayers. Large sprayers with booms up to 27 m are used on large, flat farms where they are cost-effective. They are most times mounted on tractors.

- **Motorised knapsack sprayers**

This type of equipment was commercialised after light-weight two-stroke engines were developed. A direct drive connects the engine to a centrifugal fan that is mounted vertically. The high-speed air stream is diverted through a 90 degree elbow to a flexible discharge hose at the end of which is mounted a nozzle.

This type of sprayer is widely used in agriculture in Guyana. Some models have accessories that will enable the machine to be used as a vacuum cleaner, duster, and ultra-low volume appliance.

- **Fogging machines**

Several types of thermal foggers are commercialised. One type is called the pulse jet. Each consists of a fuel tank, a pesticide tank, a hand-operated piston or bellows pump, spark plug, carburetor and long exhaust pipe. When the machine is started, combustion gases escape at high speed and the pesticide-oil mixture is vaporized. An insecticidal fog is produced. These machines may be portable, trolley or vehicle mounted and are used in fogging warehouses, ships, trees and in vector control.

- **Aerial application**

Fixed and rotary wing aircraft are used to apply pesticides. The Thrush Commander is a popular fixed wing single-engine plane used for pesticide and fertiliser application in the rice and sugar industries. A major advantage of aerial application is the speed with which large areas can be effectively treated.

Selection of equipment

The following factors should be considered carefully when selecting application equipment:

- the availability of labour
- area to be treated
- ease of use
- life span of equipment
- capital cost of equipment
- running cost
- after-sales service
- speed required to treat area
- frequency of application

In the final analysis, costs are considered versus benefits. Having chosen appropriate equipment, it is essential that the recommendations governing their safe use, maintenance and care are followed.

3.5 Application of insecticides

Having chosen a given formulation and the application equipment to be used, the next step is to apply the material. There are a number of factors to consider during application. We consider a few of the important ones here.

3.5.1 Coverage

Insecticides need to be applied to a particular target. This can be the insect itself or area occupied by it and includes parts of plants, soil, air, water, fabric of buildings, grain or even the human body. When an insect is indirectly targeted, insecticide may be applied to a surface on which the insect is found. If such a deposit contains enough of the pesticide, the insect is killed. In general, when an insecticide is applied, the aim is to have good coverage or adequate dispersion of the insecticide for good insect control. Factors influencing coverage include lack of enough water in spray applications, improper calibration of application equipment, heavy waxy covering on plant leaves, settling out of wettable powders and wind speed.

3.5.2 The insects

It is important to determine the need to apply an insecticide before it is carried out. This brings in the concept of thresholds, which was discussed in Chapter One. In essence, the infestation level of the pest must be high enough to warrant the cost of an insecticide application. In many cases, researchers through experimentation will come up with these numbers, but for many of our crops in Guyana, this is not yet possible. However, over a period of time with a given crop and a set of insect pests, you can gradually develop simple rules to determine whether to apply an insecticide or not.

It is critical to identify the insects that are considered pests. Large numbers of insects in a crop do not mean that they are causing damage. Further, all insects have a vulnerable part in their life cycle or habits. Properly timed applications that attack the weak link are most effective. Consider, for example, cutworms. They usually come out at night to feed on plants and during the day would rest in the first 4-7 cm of soil. It therefore follows that applications of insecticides to control cutworm should be made during the evenings when the cutworms begin to emerge and feed. At other times, they will be protected by the soil that will have to be drenched with far greater quantities of insecticides if the target pest is to be reached.

3.5.3 Calibration of application equipment

The main reason for calibrating spray equipment is to measure and adjust the amount of liquid that is sprayed and the area covered, so as to keep within the product-label recommendation. Consider a label recommendation for a given insecticide, which says that 405-450 L/ha (36-40 gal/ac) must be sprayed on the crop. We proceed to show how a CP3 knapsack sprayer can be calibrated to deliver this amount. The procedure adopted is that of the British Crop Protection Society (1989) and is called the **Speed-Width Output Method.** The amount of liquid delivered out of the nozzle and onto a specific area of land will depend upon:

1. The **speed** at which the operator walks over the area. If the ground is covered slowly, more liquid per area is sprayed than if it is covered quickly.
2. The **width** of the spray band. How broad this is will depend upon the type of nozzle used and how high the spray lance is held above the target to be sprayed.
3. The nozzle flow rate (**output**). Several factors influence nozzle flow rate. Nozzle type and size as well as pressure are some important ones.

If each of these three factors can be measured, then the amount of sprayed liquid can be calculated.

Calibration procedure   The Speed-width output method

Action	Activity	Example
Select nozzle ⇨	refer to CP3 manual ⇨	Hollow nozzle cone yellow type selected
Set pressure ⇨	open can and twist pressure lever to desired position ⇨	Pressure is set at 'high'
Measure time to walk 100 metres ⇨	measure time taken to spray over 100 metres by walking on similar ground that is to be sprayed ⇨	100 seconds
Calculate speed ⇨	speed (km/hr) = 360 divided by the time taken to walk the 100 metres (in seconds) ⇨	360÷100 =3.6km/hr
Measure width of spray ⇨	spray over a dry surface at a comfortable, consistent height above the target. Measure the width of the spray band in metres ⇨	1.0 m
Measure flow rate ⇨	spray into a container for one minute and empty into a measuring jug and record volume in litres/minute ⇨	2.5 litres/minute
Calculate spray volume ⇨	Vol. (litre/ha) = $\frac{\text{600 x flow rate (litre/min)}}{\text{Width (m) x speed (km/hr)}}$ ⇨	$\frac{\text{600x2.5}}{\text{1.0x3.6}}$ = **417 litres/ha**

If this calculated spray volume is outside the range given on the label (in this case it is not, i.e. 405-450 litres/ha), adjust the speed or pressure to change the volume delivered by up to 10%. If more than 10% is required, change the nozzle. Once the calculated figure is not within the desired range, the entire procedure will have to be repeated. If it is, then you can now mix your insecticide and walk at the same speed, using the same nozzle, pressure setting and spray your crop, being assured that you are getting coverage as recommended.

If you are desirous of using English units, you can use this formula

$$\text{Vol (gal./ac.)} = \frac{\text{495 x flow rate (gal/min)}}{\text{speed (mph) x spray width (ft)}}$$

If you use the same data as in the example given above, making appropriate conversions (see Appendix 2), then:

$$\text{Vol (gal./ac.)} = \frac{495 \times 0.55 \text{ (gal/min)}}{2.24\text{mph} \times 3.28\text{ft}}$$

This figure corresponds to 37 gal/ac which is equivalent to 417 litres/ha.

Many farmers may not wish to spray large areas but instead, small vegetable plots, with a number of different kinds of crops grown. In such cases, calibration could be done using a **concentration method**:

- Spray a small patch of about 11 square metres (100 square feet), or smaller, with water to determine the volume of spray that will be needed for that known area. Let's say after this exercise, the area you sprayed (100 square feet) required 20 litres (4.5 gal.).
- The next step in this procedure is to read the label's recommendations. The product label may give a recommendation in grams or mls of the product per litre of spray solution. Assume it says 10g in 4 litres of water. (i.e. that 10 grams of insecticide should be added to every 4 litres of water used).
- From step 1, we know that to spray 100 square feet we need around 20 litres. From the second step we know that 20 litres will require 50 grams (10g in 4 litres, 50g in 20 litres).

Using this method we can calculate how much water we need for our spraying activity, (by comparing it to the amount used to cover a known area) and we can calculate how much insecticide (using label recommendations) we need. After the calibration the solution is mixed and sprayed on to plants until the liquid just begins to run off. Ensure that just the right amount of spray is mixed and used so that there is reduced risk of under or over-application, both of which can be costly in terms of insect control achieved, cost of product and residues on the crop.

3.5.4 Understanding pesticide labels

A pesticide label should have a number of important features. These may include the following:

1. Trade name of the product
2. Type of formulation
3. Active or toxic ingredient name and % strength
4. Suitable warning
5. Weight of product
6. Poison symptoms
7. First aid
8. Antidote
9. Manufacturer's name and address and distributor if applicable
10. Directions for use
11. Danger to the environment
12. Compatibility with other pesticides
13. Expiry date
14. Appropriate language.

See Figure 3.1 for an example of a reasonably good label:

Figure 3.1 Pesticide label

JUPITER 50SP

100g

Water-soluble Powder (SP)

Common Name: Carbyl hydroboride

Contains: 1, 3 - bis (carbon oylfinos) - 2 - (N, M-trimethoamino) propanyl hydroboride 50%
Inert ingredients 50%

WARNING - READ INSTRUCTION

Keep out of the reach of children. May cause poisoning through the mouth. Keep away from food and feeding stuffs. Do not re-use this package; rinse and bury when empty. Use a mask when mixing or applying. Wash hands thoroughly with soap and water after handling and before eating, drinking or smoking.

SYMPTONS OF POISONING

Nausea, muscle tremors, salivation, difficulty in breathing, dilation of pupils.

FIRST AID

If swallowed, call a doctor immediately. Induce vomiting by giving a table spoon of salt in a glass of water. Repeat until vomit fluid is clear.

ANTIDOTE

An intravenous injection of 100-200 mg of L-cysteine.

Manufacturer: Tegwani Agrochemical Industries Ltd., UK
Distribution: Shiv & Sons Agricultural Supplies Ltd.
3 Charlotte St., Georgetown, W.I

Trade Name
Weight of pesticide
Type of formulation
Active ingredient
Added to formulated product
Precautions
Effects of poisoning
What to do in event of poisoning
Advice to doctor
Manufacturer and distributor

USE DIRECTIONS

JUPITER 50 SP may be used on most fruit and vegetable crops to control a wide range of insect pests. Sufficient water must be used to wet the entire plant thoroughly, including the underside of leaves.

- To control caterpillars (armyworms, cabbage worms, pinworms, melon worms, loopers, leaf rollers, pod borers, stem borers etc), beetles, flea beetles, thrips etc. Mix 10 grams in 4-5 litres (1-1.3 gals) of water [one package of 100 grams in 40-50 litres (10-13 gals) of water]. For larger areas, apply 1-1.5 kg per hectare.
- To control aphids, leafminers, crickets, white blights etc mix 15 grams in 4-5 litres of water (approximately 1/4 oz in 1-1.5 gallons of water).
- Allow an interval of at least 7 days between applications and allow at least 10 days after last application before harvesting.

JUPITER 50SP is moderately toxic to fish. Do not contaminate ponds, rivers, reservoirs etc.

JUPITER 50SP is compatible with most commonly used insecticides and fungicides other than alkaline products such as copper compounds

KEEP OUT OF THE REACH OF CHILDREN

Clear instructions for use
Frequency of application
Harvesting period
Environmental statement
Tells whether it can be mixed with other materials
Warning on storage

Note: this label is not for an actual pesticide

A critical examination of the label can help you to make decisions on whether to purchase or not. If you have decided to use the insecticide based on the label, adequate information should be provided to allow for safe and effective usage. In some countries, the law regulates what is printed on a label. Indeed, each product has to be registered before it can be marketed. Your attention is drawn specifically to the usage directions of the specimen label provided. Note the precise nature of the instructions in terms of quantities, range of pests for which it is effective, and other such information which allows for calibration.

Let us use the above label for a calibration exercise. It states that 10g is needed in 4-5 litres of spray solution. Each packet of 100 grams thus requires 40-50 litres of water. If ten packets are needed per hectare (1-1.5 kg per hectare or 10-15pkts), then 400-500 litres of water would be required. This kind of calculation is extremely important when one has to calibrate the sprayer to make sure it delivers 400-500 litres per hectare. At the lower dose range of 10 packets per hectare (i.e. 1 kg in 400 litres), this amount of liquid would amount to about 20 tanks, each of 20 L spray. Therefore, each full tank must have half of a packet or 50 grams, i.e. about 2.5 grams per litre of spray. So after calibration, one mixes the pesticide at the calculated/recommended dose and applies.

3.6 Summary

Pesticides represent an important means of control. However, bad usage can lead to producing unwholesome food and contamination of the environment. When used properly according to manufacturers' recommendations, they are generally considered effective and safe. That is why we have examined at some length topics such as pesticide formulations, application equipment, calibration guidelines for applying pesticides and interpretation of pesticide labels. However, it must be recognized that there are many times when pesticides alone cannot solve a given pest problem. Indeed, a multi-pronged set of strategies using several types of control is gradually being developed and accepted by our farmers as they prepare to fight insect pests utilising principles of Integrated Pest Management.

CHAPTER 4 CORRECT MANAGEMENT OF INSECTICIDES

4.1 Introduction

In the previous chapter we had a look at some of the basic characteristics of insecticides and gave some guidelines for their use. In this chapter we look a bit closer at the management of insecticides. In particular we look at controlling insecticide resistance through the careful planning of insecticide strategies and through the incorporation of as many of the IPM practices as possible. We also address the issue of pesticide safety.

Most growers depend on insecticides for the effective management of insects. When insecticides work, the cost of insect control usually comprises a relatively small portion of the production costs for a crop and remains a relatively minor concern to the grower. However, when the use of insecticides fails to remedy an insect problem, the cost of the insect control can become a major component of the cost of production, often destroying profitability. Insecticide resistance is one cause for insecticides failing to control insect pests. Since the profitability of many crops depends on the effectiveness of insecticides, knowledge of insecticide resistance can be of great benefit when planning an insect control program for a crop.

When there is a loss of insect control during the use of one or more insecticides, insecticide resistance is often suspected as the underlying cause. This is a reasonable response considering the efficacy of modern insecticides and the increased frequency of insecticide resistance. Loss of insect control during the use of insecticides can also result from:

- resurgence of the target pest or build up of a non-target pest, as a result of killing off the beneficial species which help keep insect populations at below economic thresholds.

- reduced product potency due to age and storage conditions, poor application procedures, environmental factors, and misidentification of the target species.

When developing an insect management program, it would be prudent to incorporate safeguards against these two potential sources of poor insect control.

Once a true insecticide resistance episode occurs, it is usually too late to remedy the situation. A considerable amount of time usually passes before the situation is studied, and enough information can be gathered to attempt to deal with the resistance. Consequently, **insecticide resistance is considered easier to prevent than it is to manage**. The management approach should be proactive, where steps are taken to prevent or delay the onset of insecticide resistance.

Since insecticide resistance is a symptom of over-reliance on insecticides, the logical thing to do is reduce the use of insecticides to the very minimum. This can be accomplished by engaging all aspects of integrated pest management (IPM) in the production of a crop. This does not necessarily excluding the judicious use of insecticides. Knowing how to manage insecticide resistance and the insects prone to developing resistance can greatly improve the long-term stability of any insect control program. Since insect pest and insecticide resistance problems can vary among regions, crops, and individual growers, providing information tailored to specific regions and crops can be of considerable value to a grower.

4.2 Insecticide resistance

What is insecticide resistance? Insecticide resistance is a condition that arises when an insecticide is no longer effective against a population of insects. A population, from the standpoint of resistance, can be as small as that within a single field or greenhouse, or as large as a country-sized region. Since insecticide resistance is usually a response to the nature of insecticide use, the levels of and types of insecticide resistance can vary greatly from region to region and even among neighboring farming operations. Thus care should be taken when moving transplants from one farming area to another. Don't spread the pest.

How does insecticide resistance develop? Insecticide resistance is the result of a natural and dynamic response of an insect population to the application of insecticide. The development of insecticide resistance is a selection process where the susceptible forms of the insect are replaced with resistant forms due to exposure to insecticide.

Where do these resistant forms come from? Insects can be said to be predisposed to develop resistance to insecticides because they have evolved mechanisms to deal with the numerous toxins found in their food plants. Since these "preadaptive" mechanisms can vary among individuals in a population, as does any trait, there are often a few individuals that are especially well adapted to tolerate insecticides. These "resistant" individuals are able to survive and reproduce in the presence of insecticides to become the predominant form in the population.

Can insecticide resistance go away? Yes. Just as resistance develops because of exposure to insecticides, the level of resistance often declines when the insecticide usage is stopped, a process called **reversion**. Reversion occurs because most resistant populations still possess individuals that can breed vulnerability to insecticides back into the population. Also susceptible individuals can migrate into the resistant population. The more susceptible individuals are often more fit than the resistant individuals in the absence of insecticides, allowing the susceptible individuals to out compete the resistant individuals. If the insect populations occur over a very large area, however, or there is little opportunity for susceptible individuals to move in, sometimes reversion doesn't occur or does so very slowly. If reversion does occur and susceptibility is restored, resistance on resumption of the offending insecticide program usually returns quickly.

4.3 Suggested steps for preventing or delaying the onset of resistance

Since it is difficult to actually manage resistance, it is better to think in terms of preventing or delaying the onset of resistance. The following guidelines are provided to help individual growers evaluate and make adjustments in their insect control programs to minimize the problems due to insecticide resistance. It is expected that the grower will have to enlist the help of professionals, such as extension personnel, professional entomologists (including those from chemical companies [many chemical companies are concerned about insecticide resistance and will probably offer advice]), and consultants to act on these guidelines.

Step 1. Evaluate your insect control program to determine the likelihood of developing resistance problems. Use Tables 4.1 and 4.2 to assist you to determine how likely you are to encounter insecticide resistance problems on your farm. Table 4.1 points out practices, factors, and conditions that will contribute to the development of insecticide resistance.

Step 2. List the crops, pests, insecticides you use and those that you don't use. Determine the amount of IPM you practice, and your ability to enlarge on your IPM program. Group insecticides by their chemical class (Appendix 1) and note preharvest intervals and other label restrictions, such as number of applications per crop or season for each insecticide.

Step 3. Develop an insect control program that targets the insect pests that you usually have problems with. Minimize the use of insecticides and, when needed, use them in a way which rotates the choice amongst the different chemical classes (Appendix 1).

- Incorporate as many non-insecticidal methods as possible in your insect management program.
- Establish some sort of a scouting program to determine if the pest of interest is even there. A rudimentary level of scouting to record presence or absence of pests should reduce the usage of insecticides. If the cost of scouting is more than the usage of insecticides in the short term, it can be considered cheap compared to the cost of dealing with a resistant insect in the future.
- If no action threshold exists for an insect pest, establish some sort of intuitive tolerance level for the pest. These tolerance levels can be adjusted with experience.

It may be necessary to enlist the help of the extension services or other consultants in this process. The end result will minimize overall use of insecticides and overreliance on any one insecticide.

Table 4.1 - Practices, factors, or conditions to use to assess degree of risk of encountering insecticide resistance problems.

Low risk	⇨ ⇨ ⇨ ⇨ ⇨	**High risk**
Insect species present with no history of resistance		Insect species present with history of resistance (Table 4.2)
Several insecticide applications per crop		One to several applications per week per crop
Spray based on thresholds		Spray based on preventative schedule (i.e. spray when the insect is not at an economically damaging level)
Use insecticides from multiple classes, (Appendix 1)		Use insecticides from single class of insecticide
No pyrethroids used (Appendix 1)		Use pyrethroids
Discontinuous cropping (crop-free period)		Continuous cropping (no crop-free period)
Propagate own transplants		Buy transplants
Good crop sanitation (destruction of crop residue)		Poor crop sanitation (leave crop residue in field)

Table 4.2 - Species with a history of insecticide resistance

Common name	**Genus and species**
Fall Armyworm	*Spodoptera frugiperda* (J. E. Smith)
Southern Green Stinkbug	*Nezara viridula* (L.)
Corn Earworm	*Helicoverpa zea* (L.)
Tomato Pinworm	*Keiferia lycopersicella* (Walsingham)
Cabbage Looper	*Trichoplusia ni* (Hübner)
Silverleaf Whitefly	*Bemisia argentifolii* Bellows & Perring
Melon (cotton) Aphid	*Aphis gossypii* Glover
Diamondback Moth	*Plutella xylostella* (L.)
Leafminer	*Liriomyza trifolii* Burgess
"Melon" Thrips	*Thrips palmi* Karny
Paddy Bug?	*Oebalus poecilus* (Dallas)?

4.4 Pesticide safety

Regarding pesticide safety, the main things to remember are:

- insecticides should all be considered poisonous to humans and treated as such, the concentrated or undiluted forms are much more toxic than when diluted.
- children are generally more susceptible to poisoning than adults.
- the most information on the safety of any insecticide should be that found on the *label* which is supposed to accompany the insecticide.

The following is adapted from the 1996 Florida Insect Management Guide (section on Insecticide Safety by Dr. Freddie A. Johnson) and the Vegetable Production Guide for Florida, SP 170, University of Florida 1995 (section on Pesticide Safety by Dr Olaf. N. Nesheim).

4.4.1 Safety precautions

Read and go by precautions on the label. Always read the label. The best policy is that if a proper label from the manufacturer does not accompany the insecticide, don't use it. Insecticide poisonings have happened because of ignorance, misunderstanding of available information, carelessness, or recklessness on the part of informed workers. Relatively few deaths occur from the handling of insecticides. The deaths that have occurred can be traced to disregard of the most minimum of safety precautions found on the label of the product.

The key to safe handling of insecticides is understanding coupled with the diligent practice of safe work habits. Accidents with insecticides are preventable. Accidents can be prevented by:

- keeping insecticides from within the reach of irresponsible people, children, pets, and livestock.
- reading and following the use precautions on the label.
- proper disposal of empty containers.
- if available, use the proper personal protection equipment (PPE) specified on the insecticide label.
- when applying insecticides, be sure to have enough clean water and liquid detergent available for drenching and washing in case of an accident. Remember that a single drop of certain insecticides in the eye is extremely dangerous. Be prepared to wash the contaminated eye for as long as 15 minutes.
- do not work with insecticides if you have a headache or are not feeling well.
- never smoke or eat while working with insecticides.
- always avoid inhaling (breathing in) insecticide sprays, dusts, and vapors. The rule-of-thumb is that if you can smell the insecticide, you are being exposed.
- always have a partner with you or close by that knows what to do when you are using highly toxic pesticides (those that have the word **DANGER** with a skull and crossbones on the label). People, pets, or livestock must not be allowed to enter a treated area until after sprays have dried or dusts have settled, or until the label designated specified time following application of a pesticide when people, pest, and livestock may **NOT** enter the treated field (Restricted Entry Interval, or REI) has passed.

4.4.2 **Poisoning**

Seek medical help if you or a co-worker have any of the following symptoms during or shortly after using insecticides:

headache, dizziness, chest discomfort, chest tightness, nervousness, blurred vision, pinpoint pupils, weakness, fatigue, nausea, vomiting, abdominal cramps, diarrhea, sweating, tears, salivation, slow pulse, muscular tremors, muscular discoordination, and convulsions

Many of the previously listed symptoms accompany poisoning from ingestion (swallowing), inhalation (breathing), and absorption (through the skin) of organophosphate and carbamate insecticides (Appendix 1).

Pyrethroids (Appendix 1) are generally considered safer than organophosphates and carbamates, however, the following symptoms can result from overexposure, principally by inhalation (breathing):

stuffy, runny nose and scratchy throat, asthmatic wheezing in susceptible individuals, bronchospasm, swelling of mouth and throat linings, shock (anaphylaxis), delayed appearance of breathing difficulty, cough and fever, patchy lung infiltrates suggesting hypersensitivity pneumonitis, nervous irritability, tremors and inability to coordinate muscular movements

A very important point to remember is that poisoning from insecticides can be cumulative, with symptoms showing up after long periods of low level exposure.

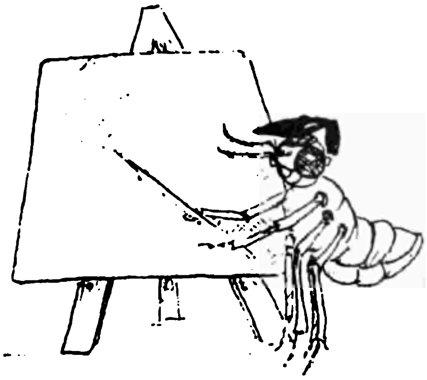
Most farmers are aware of these dangers and also of the necessary safety precautions. They have heard them a number of times. Efforts should be made to follow as many of them as possible. Just because you can't follow a couple of them doesn't mean you should discard all. The most worrying aspect of exposure to insecticides is that the poisoning can be cumulative. Little by little these chemicals will affect your health if the right precautions are not taken. Contrary to an often heard statement, Guyanese are not any more resistant to agrochemical poisoning than anyone else.

4.4.3 IN CASE OF AN ACCIDENT

Remove person from exposure.
Immediately get away from the treated or contaminated area.
Remove contaminated clothing.
Wash with soap and water.
Seek medical help.
Be prepared to give the name of the active ingredient in the insecticide to the physician. If have label or clean container, take it with you.

Further safety information can be found in the recent Guysuco publication "The Safe Use Of Pesticides" (1997).

4.4.4 SOME INSECTICIDE DO'S AND DON'TS



DO read the manufacturer's label carefully and completely, paying particular attention to precautions and antidotes.

DO wear adequate clean protective clothing and equipment as specified on the label.

DO wash immediately and thoroughly with soap and water if spray is spilled on the skin.

DO remove clothes after using poisonous chemicals and bathe with plenty of soap and water. Wash work clothes before using them again.

DO wash hands before eating and smoking.

DO confine the use of insecticides to the designated areas which are to be treated.

DO store insecticides in the original labeled containers away from food, feed or medicine; and out of reach of children, pets and livestock.

DO dispose of empty containers properly and safely.

DO call a doctor or get the patient to a hospital immediately if symptoms of poisoning occur during or shortly after spraying or dusting.

DON'T breathe sprays or dusts.

DON'T direct spray or dust stream into the wind.

DON'T allow clothing to become saturated with dust or spray.

DON'T use sprayers with leaking hoses or connections.

DON'T allow drift onto neighboring fields, particularly pasture and forage crops, or fields containing produce ready to harvest.

DON'T contaminate fish ponds, streams, lakes, and drainage ditches.

DON'T use the mouth to siphon liquids from containers or to blow out clogged lines, nozzles, and other parts.

CHAPTER 5 LOCAL PLANTS WITH POTENTIAL CROP PROTECTION USES

5.1 Introduction

This chapter takes a detailed look at the possible role of some local plants (botanicals) in crop protection in Guyana. The aim is to provide information for those interested in examining alternative control options within the sphere of integrated pest management. The information in this chapter on botanicals comes from the latest literature on the subject and from work conducted in Guyana.

> Much of the previous work on botanicals has been aimed at establishing their crop protection properties and has yet to reach the levels of "product development" found in the agrochemical industry. In no sense should the information in this chapter be used in the same way as the instructions found on the sides of a pesticide bottle. One reason for this is that by regarding information as a set of unassailable instructions, a person's natural tendency to discover and develop something for himself or herself is suppressed. This is undesirable in a field of work where we still know so little. Use the information in this chapter as a starting point for your own investigation.
>
> Also because we still need to develop much of this information, it would be unwise and dangerous to make public recommendations here on the use of botanicals. For this reason the authors do not do so.

What this chapter does offer is a record of what others have found. It also hopefully encourages interest in developing a greater understanding of the relationship we have with our natural environment.

5.2 The historical perspective

Over the centuries, human experience has developed an understanding of how plants can be used to treat certain medical ailments. Useful natural compounds are not just restricted to the field of medicine and not surprisingly there are many insecticidal compounds found in plants. Knowledge of the insecticidal properties of plants is not as developed as that of medicinal plants. Even so their use has been documented for many centuries. During the Napoleonic Wars, 200 years ago, crushed chrysanthemum flowers were used to keep lice off the French soldiers.

Apart from sulphur-based substances perhaps, the earliest, specific "insecticidal" treatments used were botanical in origin. They played an early role in the control of agricultural pests. Botanical pesticides were significantly used up to the beginning of this century, largely in the form of pyrethrum, nicotine and rotenone-based preparations. It was during World War II that, for other purposes, the synthetic organic chemicals, used in the foundation of the modern synthetic agrochemical industry, were developed. Synthetic chemicals, from their early beginnings have developed dramatically. They are a large part of the reason for the phenomenal increase in agricultural production over the last 50 years. Because of their success, the development of other control options has suffered. Much of the work on botanical pesticides was not resumed after World War II and it was relegated to the periphery of agricultural research.

5.3 The role of botanicals in modern, sustainable agriculture

Man's effort to increase the scale and intensity of his agricultural systems has been paralleled by increased pest problems. As farming systems became further removed from the regulatory balances of nature, the need to artificially control the threatening pest problems also became more and more necessary. For many years synthetic pesticides provided all the answers and agriculture prospered. Over time though the negative aspects of synthetic pesticide use became apparent. When insecticides were first used there was little thought to how the chemicals were disturbing the environment but, in time, the various related costs of some pesticides became no longer acceptable. Many of the old organochlorine (chlorinated hydrocarbon) insecticides, (e.g. Aldrin, Dieldrin and DDT), have been banned from much of the world because of their detrimental environmental effect. Even with some notable developments within the agrochemical industry, problems still exist and the insect pests are still finding ways around chemical control. Over recent times more interest has once again been shown in alternative control measures.

For crop protection to be sustainable and successful, many of the present values need to be reassessed. Crucially, alternative measures should not be appraised in the same **"all or nothing"** way as synthetic insecticides used to be. That attitude is now recognised as not being compatible with the delicate ecological balances found in nature. Any approach to successful pest management should be multi-directional and not reliant on any one individual strategy. Botanical pesticides and other botanical control methods should not be viewed as a "cure-all". They can best be used to enhance and strengthen a larger control effort. These botanical preparations have a number of traits that make them compatible for use in such control efforts:

- **they demonstrate a variety of useful properties against insects;**
- **many are non-toxic to beneficial insects;**
- **most have a very low environmental cost in terms of their production and use;**
- **most are non-persistent**; and
- **insect resistance against botanical preparations is virtually unheard of**

The use of botanicals fosters a more **interactive** and **knowledge-driven approach** to controlling pests. Monitoring insect numbers; setting pest thresholds; and timing control activities are all a necessary part of their effective use. Such actions force the farmer to accept a more personal role within his crop protection activities. The unthinking reliance on synthetic pesticides is thus replaced by a thoughtful crop protection system that has a thinking, well-informed facilitator at its centre.

21 plants are listed in this chapter, all with properties useful to crop protection. It is an abbreviated list; notes on a further 39 plants are found in Appendix 4.

5.4 African marigold (*Tagetes erecta*)

5.4.1 General

This is native to Mexico but has been introduced to many countries, including Guyana, for its ornamental properties. It is a hardy plant that survives in poor soils and low rainfall conditions. It is propagated by seed and ideally should be grown in well-drained soils. In Mexico this plant has a well-established medicinal history.

5.4.2 Insecticidal properties

Various extracts of this plant have shown toxicity, repellency and growth disrupting effects on insects.

- Root extracts in water showed toxicity to rice leafhopper and aphids.
- Whole plant extracts in water caused disruption in the normal growth of aphids, a species of stem borer and the cotton stainer bug.
- The oil extracted from the plant showed repellency to a beetle found in flour. It has possible applications against the diamondback moth. Compounds toxic to the moth have been found in the plant extracts.

5.4.3 Methods of preparation

- Trials have shown that effective extracts are taken from all parts of the plant using a variety of solvents, (i.e. water, alcohol, petroleum ether and kerosene).
- The plant parts have been dried, ground and then dusted on the crop, or mixed with a stored product to give effective control.

Additional information:

- Use of *Tagetes* species is the best-known natural method of nematode control. The roots exude a substance with nematicidal effects. Soils infested with nematodes can be thoroughly cleansed of nematodes by temporary, dense planting of the afflicted plot with *Tagetes* species. Susceptible crops to nematode damage such as tomatoes can be intercropped with *Tagetes* species on infested land.
- The leaves also contain the nematicidal properties and so incorporating chopped leaves into the soil or placing them into the planting holes, can give good protection against nematodes.
- The extracts and powder of the marigold have also shown fungicidal action.

5.5 Bellyache bush (*Jatropha gossypiifolia*)

5.5.1 General

This plant is commonly found on sandy or gravelly, open ground, especially near the sea. The pods with seeds are boiled and the liquid taken for bellyache. Boiling the leaves produces a drink that is used to relieve pain and swelling. Crushed leaves can be mixed with an oil and a soft grease, (e.g. Vaseline), to be applied externally to cuts, sore feet and ulcers.

5.5.2 insecticidal properties

Like its close relative, the physic nut tree, this plant is insecticidal. Extracts of the leaf and seeds have shown toxicity to beetles found in flour.

5.6 Black pepper (*Piper nigrum*)

5.6.1 General

Black pepper is a trailing, climbing shrub that has been cultivated in Guyana. The powder from the dried berries is used extensively in the seasoning of food. The ground green berries are boiled and the liquid drunk for the relief of flatulence. With extracts from other plants it is taken for menstrual pains.

5.6.2 Insecticidal properties

Many of the *Piper* species have proven insecticidal properties, (there are between 50-75 *Piper* species in Guyana). Most of the work has been done on black pepper.

- The dried seed powder has demonstrated repellency against the corn earworm, the bean weevil, the rice weevil and the pulse beetle.
- Extracts of the plant were reportedly insecticidal to the adult boll weevil.
- Extracts of the fruit/seed were repellant to the cotton stainer bug and toxic to various storage pests.
- The oil, used to protect grain, is toxic to the rice weevil and the lesser grain borer. It is used extensively in the protection of stored products.

5.7 Canavalia species - e.g. Jack bean, (C. ensiformis), Horse bean, Cutlass bean

5.7.1 **General**

There are at least 7 *Canavalia* species in Guyana. These leguminous plants seem to have much potential in the control of insect pests. The Jack bean is a hardy, shade-tolerant tree that does well in dry soils. It does not thrive in soils with excess water.

5.7.2 **Insecticidal properties**

Jack bean is described as being effective against acoushi ants (leafcutting ants) due to its fungicidal properties, (see Case #3 in Chapter 6 on acoushi ants). Furthermore, anecdotal evidence in Guyana claims that acoushi ant nests were deactiviated when the seeds of another *Canavalia* species were boiled in water and the resulting "tea" poured down the nests.

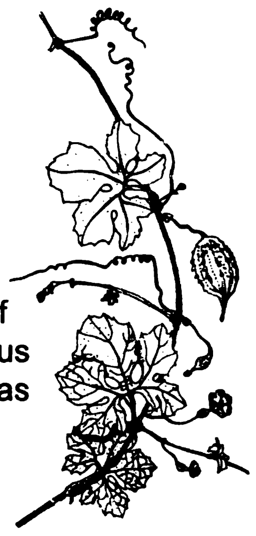
Additional information:

- The Jack bean makes a good plant for green manuring. It is planted to enhance nutrient levels in the soil through its nitrogen-fixing properties. It can be grown in between fruit trees such as coffee, where it can also help prevent weed problems.

5.8 Carailla (*Mormordica charantia*)

5.8.1 **General**

The bitter fruits from this annual vine are commonly found in the markets of Guyana. Carailla is used in East Indian cooking and also used to make delicious pickles. The tender shoots and leaves are used as a bitter tonic and also as treatment for diabetes. The juice from the leaves is taken 3 times a day to combat malaria and other fevers as well as biliousness.



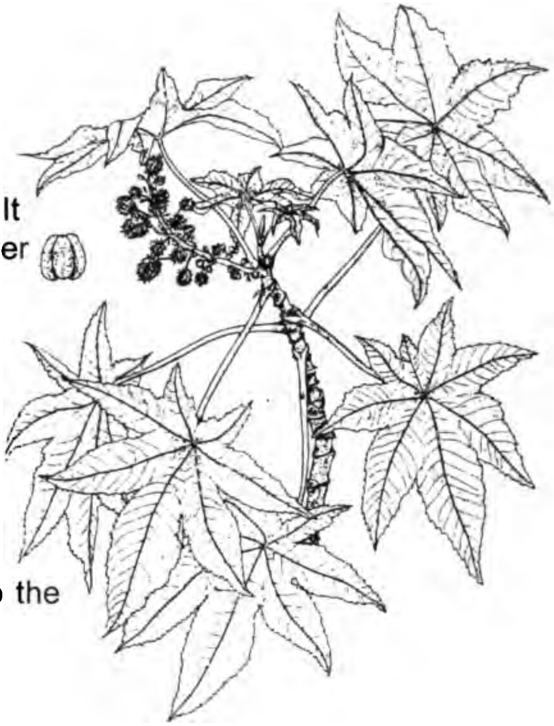
5.8.2 **Insecticidal properties**

The various chemicals within the plant, including those that cause the bitterness, are dangerous to insects.

- Whole plant extracts in water show insecticidal and antifeedant properties.
- The oil from cairailla acts as a repellant to the red flour beetle.
- A crude alcoholic leaf extract was found to show feeding deterrency when tested against red pumpkin beetle.

5.9 Castor-oil bean plant (*Ricinus communis*)

5.9.1 General



This plant's growth depends on its local environment. In Guyana it grows to become a small, short-lived tree. It looks fairly similar to a physic nut tree. It prefers lower rainfall to the precipitation levels we have here and so it should be grown on well-drained soils. It is propagated by its seeds, (healthy seeds can be kept for 2-3 years before losing their viability). **The seeds of the plant are poisonous to humans**. Pure oil from the leaves however, is not poisonous. The oil is given for the relief of constipation but use of the oil orally is not generally recommended; it is very difficult to remove all the poison, ricin, from the crude oil extract. The leaves, tied onto the head have been used to alleviate pain.

5.9.2 insecticidal properties

Previous work has shown that this plant has insecticidal, antifeedant and repellent activities on a wide range of insect pests. Most of the reports come from storage protection work. It is also used in the field as a spray or as something to be mixed into the soil before planting. In Ecuador, farmers place castor leaves in recently planted cornfields to reduce damage from ground beetles. The beetles prefer castor leaves to the corn but when associated with the leaves for 12 hours or more, the beetles exhibit paralysis. They are then killed by exposure to the sun or are picked off by the predators.

5.9.3 Methods of preparation

- The oil content in seeds can be as much as 60%. Oil can be extracted, using the dry seeds, in the same way as neem oil. (Remember that the seed cake will have most of the poison, ricin remaining in it). 5 - 10ml (1-2 teaspoons) of oil mixed with the stored product ensures good protection for 4-6 months against beetles, including weevil species. An aqueous oil emulsion can be used as a spray for protecting crops.

Note: Vegetable oils are an important part of an acoushi ant bait and for this reason castor oil could be an ideal addition to the bait mixture. In addition it has also demonstrated toxicity against acoushi ants. If the oil is slow in action against the ants, then it would represent a very useful tool against them. An interesting experiment would be to leave the crushed seeds near an acoushi ant nest and then carefully watch the behaviour of the ants. Either they will discard the crushed seeds immediately or they will take them into the nest. Here the seeds may be rejected or incorporated into the fungus gardens where they stand a good chance of having an effect.

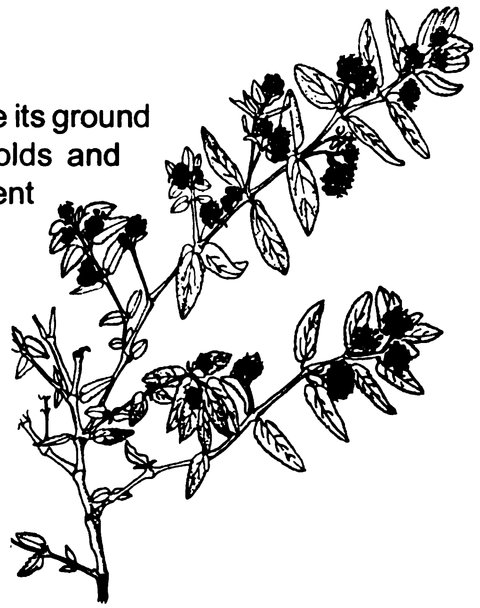
- People in Cameroon use castor oil as an insecticidal spray against a variety of pests. Take 5 glassfuls (0.5kg) of seed with the husks still on them. Crush them into a powder. Add the powder to 2 litres of water, heat for 10 minutes and then add two large spoonfuls of kerosene and a small amount of soap powder. The mixture is filtered, diluted in 10 litres of water and used immediately.
- Crushed leaves and the rest of the plant can be soaked in water and then sprayed on the crop. An aqueous mixture of 2% castor seed oil (by volume) was used to reduce numbers of sweet potato whitefly on cotton plants. Leaf extracts have been used against moth pests.
- The seeds can be crushed and dried and the resulting powder dusted onto the crop. The parts of the crop to be consumed should not be dusted and all dusting should be stopped a few weeks before harvest.

Additional information:

- Castor seed cil is active against mites and ticks.
- If land has high levels of nematodes or fungal pathogens in the soil, a proven way of protecting plants against them is to incorporate the castor seed cake into the soil a few weeks before planting. The leaf powder and aqueous extracts from the oil cake also show toxic properties against a range of nematodes.
- The seed cake also makes a good fertilizer.

5.10 Dove weed, milk weed (*Chamaesyce [Euphorbia] hirta*)

5.10.1 General



This is a common, low-lying weed species. Doves like to use its ground cover. Medicinally it is used orally to give relief from colds and flatulence. It is also used externally with ghee in the treatment of filaria.

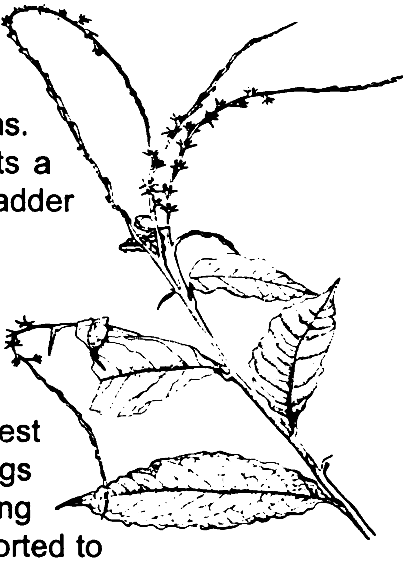
5.10.2 Insecticidal properties

It has been used against the sugar cane weevil.

Additional information:

- Several species of *Euphorbia* have shown mild skin irritant effects.
- Many other *Chamaesyce* species and closely related *Euphorbia* species have known insecticidal properties and are used successfully in other parts of the world. Fruit fly, weevils, bugs, beetles and aphids have all been target insects. There are over 10 *Chamaesyce* and *Euphorbia* species in Guyana.

5.11 Guinea hen weed, Gully root (*Petiveria alliacea*)



5.11.1 **General**

This is a deeply rooted, herbaceous shrub found in semi-shaded areas. It is propagated by its seed. When the plant is damaged it emits a strong garlic-like smell. It has medicinal properties used to correct bladder problems and to alleviate menstrual pains and other complaints.

5.11.2 **Insecticidal information**

It has been shown to be effective against a number of insect pest species including houseflies, mosquitoes, cockroaches, bedbugs, bugs and caterpillars. It works as a contact insecticide as well as a feeding inhibitor and repellent. It's whole plant and root extracts were reported to show antifeedant activity when tested against the leaf-cutting ants.

5.11.3 **Methods of preparation**

- Extracts using the whole plant soaked in water show good insecticidal properties.
- An effective powder can be made of the leaves, stems, root and/or fruits.
- Plant extracts using kerosene have also proved effective.

Additional information:

- Extracts of this plant have been used on nematodes, mites and ticks.

5.12 Hiari (*Lonchocarpus* spp.)

5.12.1 **General**

In Guyana this woody climber is especially well-known to those who live in the interior areas, for the plant mostly grows in the forest. Black Hiari, (*L. chrysophyllus*) and White Hiari, (*L. martynii*) are best known for their use in poisoning fish. In fact 10 *Lonchocarpus* species have been found in Guyana. Medicinally there are many uses. The bark is used as a tranquiliser to treat snakebites and boiled with other plant parts to relieve mucus build up in heavy coughs. The root soaked in hot water makes a liquid that is used to treat venereal diseases. For its use in poisoning fish, the root is pounded at the side of a body of water. The juices running into the water stupefy the fish and if the water is not running the fish eventually die. The plant has a preference for heavy soils of the lateric type.

5.12.2 **Insecticidal notes**

Another *Lonchocarpus* species in Guyana is Red Hiari or Faifaya-Noroko, (*L. rariflorus*) which has been used to kill insects for some time. The roots contain the highest concentration of the poison, (of which rotenone is the most toxic constituent). Rotenone is a selective, non-systemic insecticide that can also be used against some mite species. It has a low persistence in the environment and is quickly degraded by sunlight. It is also degraded quickly by an alkaline medium. The references quote that rotenone's toxicity to mammals ranges from "not at all" to "fairly toxic". It has shown to be effective against the following insects: aphids, caterpillars, thrips, and some beetles. In Africa, an aqueous solution of a rotenone-containing fish poison was used to protect young citrus trees against termites in the dry season. It was sprayed as a drench around the trees. In insecticidal trials in England on the roots and stems of hairi, it was found that extracts of both were successful. Four times as much stem material was needed to get the same results as the root extracts. White Hiari is more toxic to insects than Black Hiari.

5.12.3 **Methods of preparation**

- The dry root is ground into a powder and mixed with a carrier like a fine soil. The carrier makes the root powder go further. Powders are usually used for protecting seeds or sprinkling into planting holes to prevent insect attacks. The powder can also be mixed with water and sprayed.
- To make an aqueous solution you can pound the root directly into the water or just soak a chipped root in water overnight. If using stem you need more than you would root. In Guyana, results from work on the banana root weevil showed that 50g of pounded Black hiari stem soaked overnight in 1 litre of water, was not enough to kill the adult weevils.

5.13 <u>Sijan tree, horseradish tree, moringa tree (*Moringa oleifera*)</u>

5.13.1 **General**

This truly is a multipurpose tree. Its uses are briefly listed below.

- The unripe fruits, leaves and flowers can be eaten as vegetables.
- When the plant is only 60cm tall, it is pulled up, the root scraped to get all the bark off and then ground up. Vinegar and salt is added to make a very good substitute for horseradish, (hence the name of the tree).
- The tree's greatest use is probably its ability to purify water. It cleans very dirty and polluted water. The seed coats and wings are removed and the white seeds crushed to a powder. This is mixed with water, (2% powder by volume). It is shaken for 5 minutes to give an improved extract and then poured through a cotton cloth to filter. This liquid can then be added to dirty water, stirred fast for a least 1 minute and then stirred slowly and regularly for another 5 minutes. Wooden stirrers should be used. After stirring, the treated water is then covered and left to settle for at least 1 hour. If the water is very dirty, the dose used should be 1-1½ seeds per litre of water.

- The leaves are high in vitamin A and a small amount of dried leaf powder added to *food* gives much of the daily vitamin A requirement.

5.13.2 **Insecticidal properties**

It has been shown to be effective against cockroaches and bugs. It acts as an insecticide and a growth disrupter.

5.13.3 **Methods of preparation**

Aqueous extracts made from the branches, leaves, seeds and/or bark have insecticidal properties.

Additional information:

- Because of its other uses, work into its insecticidal properties has lagged behind. It is not recorded whether the oil or seed cake is insecticidal. To extract the oil when no oil press is available, roast or parch the seeds, grind them and then add to boiling water. The oil floats to the surface.
- It is nematicidal. Aqueous leaf extracts, (using 10% leaves per unit volume), work when mixed into nursery soil mixes. Juice pressed from the roots also works when applied to the soil.

5.14 Hot pepper (*Capsicum frutescens*)

5.14.1 **General**

This is a common vegetable found in Guyanese markets and it is used extensively in cooking. It has been known in this part of the world long before Columbus. The plant can be quite easily grown but care must be taken against waterlogging as leaf drop occurs. Light, well drained, loamy soils, preferably not too acidic, are best. If rainfall is too heavy there is a decrease in the number of fruit produced and often fruit rot occurs. This plant is grown from the seed.

5.14.2 **Insecticidal properties**

Everybody knows what happens when you use too much pepper on your food. Well you can imagine what a pepper solution would do if sprayed over an insect. The ripe fruit and seeds contain the insecticidal compounds. Pepper is effective against a number of pests - ants, aphids, caterpillars, rice weevil and various beetles to name a few.

5.14.3 **Methods of preparation**

- 300g of peppers are finely ground using a kitchen mill or a mortar. Take care not to get any of the pepper on you - it burns! Protect your hands by using gloves during preparation and if this is not possible, rub oil into your hands before you work with the fruit. The ground peppers are added to 2 litres of water and then left for at least 7 hours, preferably overnight. After this period a further 4 litres of water and half a handful of soap is added. This mixture is filtered and then sprayed.
- A powder can also be made of the peppers dried in the sun. This powder can be very effective in keeping pests away from stored products. Real care should be taken with this powder - do not get it into your eyes, nose or mouth. Also if the stored products are not completely dry, the pepper taste will taint the rice, beans etc..

Additional information:

- Before spraying the whole crop, spray a couple of plants to ensure that the solution is not too strong and will not burn your plants. For this reason it is best not to spray during the heat of the day. Wait until late afternoon or early morning.
- As it is not a systemic solution you will get maximum benefits if you make sure all parts of the plants have been wetted by the spray.
- Pepper solutions are supposed to have virus-inhibiting properties. The use of peppers here is a preventative one and so will not work once a virus has established itself. The virus-inhibiting ingredient is present in all parts of the plant, although extracts from leaves and flowers showed the highest concentrations and roots the lowest.

5.15 Lemon grass (*Cymbopogon citratus*)

5.15.1 **General**

This is a well-known grass in Guyana. It grows in characteristic clumps and is found worldwide. It has been known for over 3000 years. The ancient Egyptians, Greeks and Romans used it for medicinal and cosmetic purposes. In Guyana it is used as a tea primarily. It is also used with other plant parts to make a liquid drink for the relief of fever, jaundice and other ailments. This plant can be propagated by its root cuttings, which are replanted by hand. The bushes reach maturity after two years and can then be harvested up to 3 times a year. Eventually new plants will have to be grown on a fresh plot of land.

5.15.2 **Insecticidal properties**

As well as being toxic to insects, lemon grass also works as an antifeedant and a repellent. Merely rubbing fresh leaves onto a surface keeps flies and mosquito away. Lemon grass has proved effective against mosquitoes, houseflies, biting flies, aphids and some storage pests.

5.15.3 **Methods of preparation**

- The oil can be obtained from freshly cut leaves and stems by subjecting them to steam distillation. The oil produced smells strongly of lemons and can be used in flavouring, perfumery and in soaps. An individual could easily set up a small production system to produce this useful oil. Like neem, it could be developed into a small business, where insecticidal products are sold to farmers whom, because of the preparation efforts required, would not have the time themselves. The oil could be used as an insect repellent or made into an emulsion with water and sprayed onto crops.
- An extract of the juice obtained by pressing out the roots and diluted with water has been also be used effectively to control pests.

Additional information:

- Lemon grass also shows activity against nematodes and mites. Where a plot of land suffers from nematodes, planting the grass results in a rapid drop in nematode numbers.
- The oil from citronella grass, (*Cymbopogon nardus*), a close relative of lemon grass, also acts as a feeding inhibitor and repellant. However on fruit fly species it works as a strong attractant. This property is very useful for fruit fly control as discussed in Chapter 6 (Case #1- on sapodilla fruit fly).

5.16 Mammey (*Mammea americana*)

5.16.1 **General**

This is a large, evergreen tree which produces the fruit commonly found in the markets of Guyana. The tree grows to a height of 20m and each tree can yield up to 300-400 large, orange-fleshed fruit annually.

5.16.2 **Insecticidal properties**

The ripe seed contains the highest levels of the insecticidal compounds although all other parts of the tree also contain small amounts of the insecticidal substances. Each fruit encloses from 1 to 4 large seeds and around three-quarters of the fresh seed is made up of a creamy, white kernel - this contains the insecticidally active part. Interest in mammey's insecticidal properties has a long history. In the 1930s there were collections and trials of plants native to Guyana and these studies showed that mammey's insecticidal properties ranked amongst the very highest. Little seems to have been done to develop mammey's potential. In recent trials, the powder from dried mature seed kernels consistently showed powerful insecticidal effects. In the literature aphids, diamondback moths, caterpillars, beetles, weevils and ants have all succumbed to mammey. It works as a contact insecticide and stomach poison and has also shown repellent properties.

Work has shown that mammey powder kills acoushi ants on contact. Coarsely ground mammey seed powder was picked up by acoushi ants when distributed around the nest. No report was made as to what effect this had on the nest's activity. Another incomplete study was the protection of newly planted banana/plantain suckers against the banana root weevil (*Cosmopolites sordidus*). The larvae of this insect causes extensive damage to the roots of banana and plantain plants. In laboratory trials the powder killed the weevils when associated with it. Field trials, where the powder was sprinkled in the planting hole and over the trimmed parts of the suckers, were never completed.

5.16.3 **Methods of preparation**

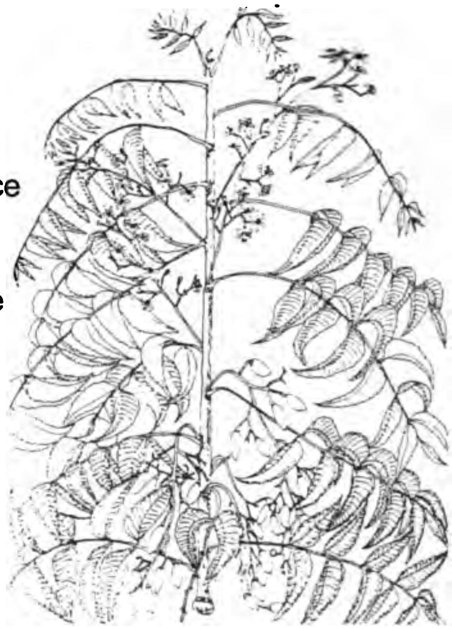
The most useful form for crop protection seems to be the dried powder of the seed kernel.

- Break open the rough brown seed coat and extract the creamy, white kernel. You may have to leave the seed in the sun for a day or two, to allow the kernel to shrink, making it easier to separate from the seed coat. The kernel is then cut into slices and laid in the sun to dry. If the slices are thick you will have to turn them over so that they dry properly. Once the slices are a dry brown, they can be pounded or milled to produce the powder. Seeds from just a few fruit gives a lot of powder, even so if you have to use the powder over a large area you may have to "dilute" it using a fine dust. This mixture is supposed to work well against diamondback moth on cabbage. The powder is sprinkled over the cabbages, preferably early in the day when dew is still on the leaves, so that the powder sticks
- Aqueous extracts are reported to be obtainable when soaking the mammey powder in water. This was attempted in the recent work in Guyana, however all that was obtained was a thick porridge. Perhaps a lot less powder should have been used. Previous fieldwork did show insecticidal activity against aphids and butterfly larvae when 8 lbs of powder were soaked in 100 gallons of water.

Additional information:

- The mammey powder is a very good proposition for crop protection in the field. Work has shown that after 4 days of sun, wind and dew the powder was still an effective poison.
- Mammey can also be used against nematodes.

5.17 Neem (*Azadirachta indica*)



5.17.1 **General**

This tree, native to S.E. Asia is viewed with religious significance in certain parts of the world due to its long list of useful properties. In Guyana it is common, found especially in the yards of East Indian families. Twigs can be used as toothbrushes; a tea made from the leaves is used in the treatment of intestinal worms, ulcers, skin problems and jaundice; and a bath of the leaves is used to treat measles. In India they have also found contraceptive properties. These uses are only the tip of the iceberg.

5.17.2 **Growth**

It is a fast growing tree that grows well even on poor soils. Rainfall is also not normally a constraint although flooding can kill the tree. Neem trees can be planted from fresh seeds, (which need to be planted within 2 weeks after seed drop. Seeds will not germinate if left longer than that). Place 2-3 seeds together, about 1cm deep, in loose soil. If all germinate, only keep the strongest. After 9-12 months the seedlings reach a height of 150 - 200cm. The seedlings must be taken care of by regular weeding; they are very sensitive to competition from weeds. Neem trees normally produce fruit after 3 to 4 years. They normally bear fruit once a year, sometimes twice. The fruit when ripe is yellow, oval and around 2cm in length. The fruit contains one or sometimes two seeds. You can manage your tree depending on what you want out of it. You can prune the tree, which then responds by becoming bushier, producing more leaves. If a grower wants to collect the seed then no pruning should be done, or only light pruning after the seeds have fallen. This is because a pruned tree produces fewer seeds.

5.17.3 **Insecticidal properties**

It has been shown to be effective against over a hundred different species of insects. See Table 5.1 for neem's varying effectiveness against different insect types. It does not have to kill insects to prevent them from causing damage to the crop. Neem also works as an antifeedent, a repellent and a growth and reproduction inhibitor of insects.

Table 5.1 - Range of neem's effect on insect pests.

Level of Control	Insect Pests
Very good control of:	- butterfly and moth caterpillars - beetle larvae
Good control of:	- grasshoppers - leafminers - leaf and plant hoppers
Fair control of:	- adult beetles - aphids - whitefly
Poor control of:	- mealybugs/scale - adult bugs - "worm" in fruit - mites

In Guyana neem is already used to protect stored products like beans, peas and rice. A few leaves in a bag works well, (it is recommended that a handful of leaves is added for each kilogram of produce).

5.17.4 Methods of preparation

For storage protection purposes, the neem seed oil is often used. The production of this is described below.

- **neem seed oil**. The chemicals in neem oil break down in sunlight and so it is best to make the oil under shade. Collect the ripe seeds from the tree or the ground, where they have fallen. The pulp of the seed should be removed before drying. Drying should take a few days of good sun. Once dry the seeds can be stored in the dark for a year without losing their effectiveness. To prevent mould developing, the seeds should be stored in containers that can let air through them. To extract the oil, dried seeds should be shelled by cracking the seed with a stone or with pounding in a mortar. The inner seed or kernel should be separated from the husk by winnowing. If the crushed seeds are very hard and brittle they should be moistened and left to stand for several hours until they can be pressed together by hand. Crushing the seeds in a mill or mortar produces a rough, sticky mixture out of which oil can be pressed by kneading. Repeated kneading and squeezing removes the oil. Adding a little water usually helps the extraction. The solid remaining after the oil has been extracted is called the neem or seed cake. Using the method given above, 100-150ml of oil, (4-5 tablespoons) can be extracted from 1kg of dried inner seed. This doesn't seem a lot but you only need a little to protect your grain - 6 tablespoons of oil can do 30kg of the stored product. The beans or grain should be well mixed with the oil. Neem oil gives long lasting protection, (over a year), whereas leaves have to be replaced to give continued control. Neem oil is bitter, (but non-poisonous), for the first 3-4 weeks of treatment but then the taste starts to diminish. To remove the bitter taste before eating, the beans or rice should be covered with hot water for a few minutes and drained.

Neem can also be prepared as a crop spray. Below are two methods.

- **Aqueous neem seed extract**. 500g of dried seeds are crushed in a mill or mortar and then added to 10L of water, stirring vigorously. This mixture is then left overnight before being filtered; fine mosquito mesh is good for this. When needed, half a handful of soap powder is added to help the neem mixture stick to the plant. The mixture can be stored in the dark for 3-4 days before it loses its potency. This preparation has been used effectively against caterpillars, grasshoppers and certain beetles.

- **Aqueous neem leaf extract**. 1kg of leaves are bruised and crushed. Place these in a bowl of hot water for 15 minutes or overnight in cold water. After this time water is added to make the total volume up to 8 litres. This is then filtered and half a handful of soap powder added.

Neem powder can also be applied to crops. Again there are two methods of preparation.

- **Neem seed powder**. The dry seeds should be cracked and the inner seed or kernel separated from the husk. The kernel should then be partially crushed, dried, (out of the sun), and then further pounded to produce the powder. This powder has mostly been used for the protection of stored products. It can also be used in the field, in a suspension with water or as a dust incorporated directly into the soil. In the soil it will protect seedlings from ground pests. In some cases it has shown systemic properties.

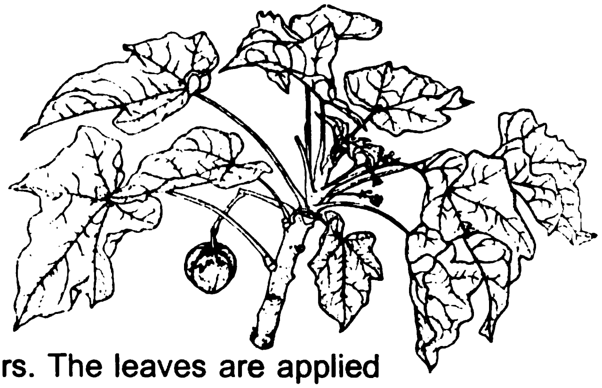
- **Neem leaf powder**. The leaves are picked and dried in the shade. When the leaves have dried they are crushed with a mortar and pestle to produce the dust. There has been little trialling of this powder, outside of its use in protecting stored products. Reapplication of neem in the field is usually necessary; after 7 days cf sunlight neem loses 50% of its effectiveness. In areas of vegetable cultivation, with large pest problems, weekly applications may be necessary.

Additional information:

- Present knowledge indicates that neem preparations seem to have had virtually no effect on the wasp family. Members of this family are useful pollinators and parasites of pest insects. Neem also does not have an effect on bees.
- In India there are people in communities who make a living by producing neem products for sale to farmers. Because the preparation of the neem products can take time, it makes sense for somebody to specialise in it. Neem cakes are often the product sold. This small-scale production could be attempted here.
- Some of the latest products released onto the agrochemical markets are based on neem extractions and synthesised neem products. **Repelin, Margosan-O, Neemark, Welgro, Neemix, Azatin, Neemrich, Meol, Vemidin, Nemidin** and **Achook** all contain neem compounds. The only difference between the natural product and the manufactured ones is that the manufactured ones have other chemical compounds added to aid the general effectiveness of the products in the field. Primarily, the chemicals added are there to increase length of activity in the field, adherence to the plant and the like. The danger of synthesised botanical products is that there is a narrow spectrum of effective constituents found within the product as compared to natural sources. This increases the risk of insect resistance developing. Naturally, the neem plant contains over ten different types of

chemical compounds biologically active against insects. It would be virtually impossible for an insect to overcome all.
- Neem also has an effect on nematodes and fungal diseases.
- Wood from the neem tree is a strong and termite-resistant and could be well utilised as building material.

5.18 Physic nut (*Jatropha curcas*)



5.18.1 **General**

This small tree is a native of tropical America and a well-known plant in Guyana. It has a number of medicinal properties. These include relieving menstrual pains, headaches and abdominal disorders. The leaves are applied locally to painful or swollen areas. The seeds are taken orally for some ailments but some of the literature quotes that the seeds are poisonous. Physic nut is easily grown from its seed but care must be taken to avoid waterlogging of the plant. Light soils are usually best.

5.18.2 **Insecticidal properties**

Much of the work on this plant has been done in S.E. Asia, and has been primarily targeted at the pests of cotton, (bollworm and flower weevil). Recent work has targeted weevils and other stored product pests of rice and beans. The oil from the seed shows the greatest insecticidal activity. The oil forms a uniform suspension with water, (and can thus be regarded as an emulsifiable concentrate, EC). This means that it will not clog the nozzle of the knapsack sprayer.

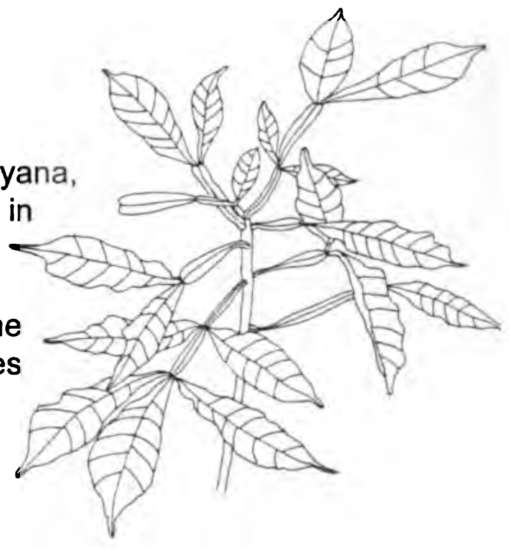
5.18.3 **Methods of preparation**

- The oil can be made using the following method. Gather mature fruit of physic nut and dehull the seeds. Grind these into a fine powder and soak in a solvent like 96% alcohol, or petroleum ether, (kerosene or petrol work as an alternative). This is left for 2-3 days before the solvent fraction is carefully poured off into a wide-mouthed container. The solvent is then allowed to evaporate off leaving the crude oil. 300ml of this oil is mixed with 3L of water and sprayed onto the crop. To begin with a small portion of the plants and pests should be tested.
- The dry seeds could perhaps be crushed and mixtures prepared in the same way as for the annona (soursap, custard apple etc.) seeds - i.e. as an aqueous emulsion.
- The dry seeds can be crushed and made into an insecticidal dust.

Additional information:

- The oil does not persist in the environment and is not harmful to beneficial insects.
- The dust has been successfully used against snail pests of rice crops in the Philippines.

5.19 Quassia, quassia bitters (*Quassia amara*)



5.19.1 **General**

This is a small, 4-6m tall tropical tree. It is used medicinally in Guyana, making use of its extreme bitterness. The woody stem is soaked in high wine or water and the extract is taken to restore loss of appetite and as a bitter tonic to decrease blood-sugar levels. Roots are used in the same way to treat fever including malarial fever. The stems and leaves are boiled and the liquid used to treat measles and smallpox.

5.19.2 **Insecticidal properties**

One of the earliest insecticidal applications of quassia was around 1880, when it was used successfully in the field against an aphid pest. Since then it has proven successful against the following pests: diamondback moth; various caterpillars; leafminers; and a number of beetle pests. Its mode of action is as a contact and stomach poison. Quassia is one of the very few botanical preparations which has demonstrated systemic properties. Work in Guyana showed quassia to be the most effective at controlling leafminer ("chinese writing") pests in red bean when sprayed on the leaves and around the base of the plants. Four different chemical compounds have been found in extracts of quassia and all are biologically active against insects. It is the wood principally, which contains the insecticidal compounds. All preparations of quassia should be used quickly due to rapid degradation of the insecticidal components.

5.19.3 **Methods of preparation**

Aqueous solutions are easy to make and they do work well. Below is a method that produces an effective botanical pesticide.

- 270g of quassia wood is chipped, placed in 6 litres of water and boiled for 30 minutes. After boiling, water is added to bring the volume back up to 6 litres. It is then filtered and a half a handful of soap powder is added to help the mixture stick to the plants.

Quassia is one of only a few botanical pesticides which has reported activity against mealybugs. The following method makes a quassia/tobacco mixture that is supposed to kill mealybugs.

- Simmer 150g quassia chips in 3 litres of water for 1 hour. Once off the heat, a cigarette is added and the whole mixture allowed to stand. A handful of soap powder and 12 litres of water is added before spraying.

Additional information:

- Quassia shows activity against nematodes.
- Quassia doesn't harm benficial insects like ladybirds and honeybees.

- In some instances the bitterness of the quassia can be detected in some treated agricultural produce. In tests in Guyana on red bean, using very high concentrations of quassia, this phenomenon was not noticed.

5.20 Ryania or kibihidan (*Ryania speciosa*)

5.20.1 General

This is an evergreen, understory tree found in the rainforest of Guyana. It grows on white and light brown sands, with known areas of concentration being at Tapakuma creek (Region 2), Makauria creek, Kamwari creek, Tiger creek (all tributaries of the Essequibo river) and at the East Kaburi river. Another species of Ryania is found in Guyana, (*R. pyrifera*). This is also insecticidal.

5.20.2 Insecticidal properties

The active substances in Ryania are more stable than those found in the pyrethrin and rotenone-bearing plants. Extracts thus have an ability of remaining active in the field for longer. Studies have shown that the insecticidal compounds can stay active for 5-9 days. The insect toxin acts slowly but is very effective. Eating, movement and breeding gradually cease after contact. It also works as a stomach poison. Due to its 'slow kill' it has the properties for a potential insecticide in acoushi ant baits. It has proved toxic against certain beetles, moths, caterpillars and some bugs. It was not successful against flies, thrips, aphids and mites. The insecticidal components are found both in the stem and the roots but more so in the latter.

5.20.3 Methods of preparation

Ryania can be used as a powder or a spray.

- Ryania powder is prepared by finely pulverising dried roots, leaves and stem. The powder is then mixed with an inert filler such as a fine dust. Using the powder alone would be a waste; a lower, diluted concentration would work just as well and then the mixture could be used over a bigger area. Mix the powder and inert filler to a 1:1 ratio and increase the amount of powder if necessary.
- Aqueous ryania spray. The dust is prepared as before and then 30-40g of the neat powder is dissolved into 7-8 litres of water and filtered. This preparation has been used against moths, caterpillars and beetles.

Additional information:

- Toxicity to vertebrates is low.

5.21 *Annona* species - soursop (*Annona muricata*), custard apple (*A. reticulata*), sugar apple/sweetsop (*A. squamosa*)

5.21.1 **General**

These small trees are native to South America and are commonly found in Guyana. They are usually grown from seed but can be budded or grafted onto seedling rootstock. They do not have specific soil requirements but they will not tolerate waterlogging. The trees come into bearing in 3-5 years after planting.

5.21.2 **Insecticidal properties**

Insecticidal compounds are found in all parts of the trees, except for the flesh of the ripe fruit. Extracts from the annona species act as a contact and stomach poison but they also have repellant and antifeedant properties. They have been used in the past against aphids, diamondback moth, rice plant hoppers, grasshoppers, bugs and some beetles. The custard apple is the most effective of the three species at killing insects.

5.21.3 **Methods of preparation**

Little field work has been done on these plants and so there are no exact methodologies to follow. The seeds are usually crushed to a fine powder and mixed with an inert filler before use. This powder can also be added to water and used as a suspension.

- Insecticidal activities are greatly improved by making extracts of the seeds with a solvent other than water. Soaking the crushed seeds in something like petrol, kerosene or a strong alcohol would increase the concentration of the insecticide. These extracts could not be used on living plants. Perhaps other non-agricultural uses could be tried with these extracts - to kill ants for example.

Additional information:

- The poison in the annona species is slow acting, taking 2-3 days to set in. This slow-acting poison is the sort of insecticidal compound which could be used in the local production of acoushi ant baits. Maybe the crushed seeds alone could be placed near the nest to see if there is any pick up and subsequent effect on the nest activity.
- Be careful when you crush the seeds of sugar apple that none of the powder gets in contact with the eyes. This causes great pain.

5.22 Sweet sage (*Lantana camara*)

5.22.1 **General**

This is a very common roadside flower. It grows well in disturbed areas and it is well known to many. Medicinally, the dried plant is used with lemon grass for colds, hypertension and fever.

5.22.2 **Insecticidal properties**

This plant has been used in many ways against insect pests and in particular against storage pests.

- The dried leaf powder has shown antifeedant activity when tested against the rice weevil. It has also been spread over stored potatoes, protecting them against the potato tuber moth.
- Extracts from the wood showed toxicity to the corn weevil.
- The leaf and flower extracts showed antifeedancy and toxicity when used against a beetle pest of stored red pea.

In the field:

- Leaf extracts in water are toxic to certain aphid species and caterpillars and repellant to the diamondback moth. These aqueous extracts also have shown antifeedent properties to certain caterpillar species.
- Aqueous extracts of the stem showed growth disrupting properties against certain caterpillars.
- Extracts from the flower were used as a contact insecticide on the brown rice planthopper.
- The dried leaf powder showed insecticidal, antifeedant and repellant activities against the Asian corn borer (a moth larva) and an aphid species.
- Extracts from the wood caused growth disruption of the cotton stainer bug.

Additional information:

Lantana camara is toxic to cattle, sheep and goats. It is the leaves that contain the toxic compounds. Activated charcoal given orally protects the animal against sweet sage poisoning. Activated charcoal can also be given as treatment once the animal has been poisoned.

5.23 Tobacco (*Nicotiana tabacum*)

5.23.1 **General**

Tobacco was originally found in S. America but now is grown throughout the world. Tobacco needs strong sunlight, rain during its growth period and drier weather for ripening and harvesting. Soils are important - tobacco does not stand waterlogging. Suitable soils are usually acidic with a pH of 5-6.5 and are often light with a relatively high sand content. There are 60 species of nicotine-containing plants in the tobacco family; 2 species alone are used for the bulk of the world's production of tobacco; 30 species are found only in South America. Nicotine could be extracted from the indigenous species found in Guyana. Amerindians in Guyana do smoke the leaves of certain indigenous plants.

5.23.2 Insecticidal properties

Nicotine, extracted from the tobacco plant, is a powerful nerve poison that has been used as an insecticide for over 100 years. Tobacco sprays have been used successfully against aphids, cabbage worms, caterpillars, flea beetles, leafminers, thrips and weevils. The nicotine concentration is highest in the stalks and leaf ribs of the tobacco plant. The insecticide can be made from fresh leaves or cigarettes. Nicotine kills insects by contact and also if inhaled or eaten. The top leaves and stalks have the highest levels of nicotine. When the flower buds are formed, the inflorescence and top-most leaves are broken off by hand. This is called topping. Low topping of the plant causes increase in the size, thickness and nicotine content.

5.23.3 Methods of preparation

- Soak 1kg of bruised tobacco stalks and leaves in 15 litres of water for 1 day. Filter the mixture using a mesh or something similar. Add half a handful of soap powder as an adhesive.
- Crumble a cigarette into 1 litre of water. Leave this to stand for at least 7 hours. After this period add a further 5 litres of water and some soap powder.
- Tobacco dust from grinding dried leaves can be used to treat seeds or young seedlings against pests.

Additional information:

- Nicotine is very poisonous to livestock and humans. The nicotine in half a cigarette is said to be enough to kill a full-grown man. You must not breathe in the spray or wet the skin or clothes with the spray liquid. All spraying equipment should be cleaned after use. A food crop should not be harvested for 3-4 days - the period it takes the nicotine to decompose.
- Tobacco sprays are more effective at higher temperatures, (i.e. over 30°C).
- In one study, beans and wheat were protected from a fungal disease called rust, by using a nicotine spray.
- Tobacco spray has also proved itself effective against mites.
- Tobacco dust on young sweet pepper can prevent a viral leaf-curling disease. The powder should not be used near harvest time.

5.24 Tulsie (*Ocimum sanctum*)

5.24.1 General

This is a native plant of Asia, brought over to Guyana by Hindus who view it as a sacred and medicinal plant. A tea made from this annual herb is used as a treatment for chest colds and some stomach pains. Juice from the leaves is dripped in the ear to alleviate earache. It is also used as an antiseptic agent.

5.24.2 Insecticidal properties

It has many properties:
- as an insecticide against armyworms, bugs and leafhoppers;
- as an antifeedant to caterpillars;
- as a repellant to leafhoppers;
- and as an attractant to a particular fruit fly family.

Methyl eugenol, a very powerful fruit fly attractant, is found in the oil extracted from the leaves. This attractant wouldn't work on most of our fruit fly species, (ie. the guava, sapodilla or West Indian fruit fly) but would on the carambola fruit fly.

5.24.3 Methods of preparation

- Plant extracts in water have commonly been used in previous control activities.
- The oil from leaf extracts contains the fruit fly attractant.

Additional information:

- Another *Ocimum* species, Married-man-poke, (*O. micronthum*) is found in Guyana. It too may have insect control properties. It does contain methyl eugenol.
- Tulsie has antifungal and antibacterial activity.
- The entire plant may be placed in chicken pens to keep away mites.

Note: The insect species mentioned in this chapter are trial species and were used in studies to demonstrate the activity of the plant extracts. The properties of the plants are, however, not just restricted to these insect species alone. We are a long way off from determining the full range of target insects for these plant species.

5.25 Future work in the development of botanicals in Guyana

Most of the work on botanical pesticides has been done in Asia and North America. Although some of the plant collection trips have come to this part of the world, there has been no significant study into the insecticidal properties of plants in Guyana. The list compiled above consists mostly of plants whose properties were determined elsewhere but which can be found in Guyana. Like the insects of this country, there are still many plants in Guyana yet to be recognised by science. How many of these have properties that can be used in crop protection?

How can plants control insect damage?

Plants have many ways to avoid being eaten, (unless they want to be eaten - their fruits for seed dispersal for example). Thorns, hairs, growth patterns and most importantly chemicals, form a natural defense system against attack - everybody has bitten into a hot pepper and knows how that feels. Some of the compounds kill insects outright; some make eating the plant unappealing; others affect the reproduction and development of the insects, which reduces their numbers. The chemical compounds can blister, itch, burn, irritate and kill. All these properties can be used in our favour if we know how to use them. A good place to look for insecticidal properties is in plants that demonstrate other known properties. Often a plant will show medicinal and insecticidal properties as well as others – poisoning fish for example.

5.26 Making your own botanical preparation

There are a couple of good reasons for trying to make and test plant preparations yourself. The first is that the list given in this chapter is only a start. There must be many more plants with useful properties. Secondly, all botanical preparations vary somewhat because of the natural differences you find in the same species of plants, from different parts of the world. Somebody in China may have found one thing with lemon grass, but this doesn't necessarily hold true for our lemon grass here. Find the best method of preparation for your pest requirements.

Anybody can use simple methods to test if a plant has useful properties or not. If you are looking for new plants to investigate, where do you start? Below are some points that may assist you in choosing a trial plant.

Plants which could be tried:

- *those with medicinal or other such properties, (fish poisons for example);*
- *plants that you know or have heard about which kill ticks, "jiggers", "bete rouge", fleas, lice, mange on dogs etc.;*
- *plants that never seem to be troubled by insects;* and
- *plants that are in the same family as those with known insecticidal properties.*

Once you have decided on which plant species you will experiment with, you then need to decide what type of preparation is going to be used. Below are some ideas.

5.26.1 Aqueous extracts

These result in a liquid preparation. In essence a "tea" is made. The plant part is placed in what is termed a "solvent", usually water but it could also be alcohol, petrol, kerosene etc. The plant part may be bruised or shredded to improve the extraction process or perhaps dried before being placed in the solvent. There are also differences in how the extractions are done. The preparation could be boiled or alternatively soaked in cold water overnight. This needs to be tested, for example boiling may destroy the useful ingredients in the plant or it might bring them out.

5.26.2 Powders

The plant or plant part is dried and then ground into a powder. The means of drying may affect the final product. Sun drying is easiest but can take time. If an oven or other dryer is used, note should be made of the temperature; high temperatures may affect chemicals within the plant. Direct sun may also have an effect.

5.26.3 Oils

These usually represent a very concentrated form of the active ingredient and small amounts can be very effectively used. There are various methods of extracting oil from plant parts. Most people are familiar with making coconut oil at home. The basic principles of oil extraction are:

- heating the plant part to release the oil within, making it easier to extract.
- crushing the plant part so that the oil is free to come out.
- leaving the preparation so that the oil separates out.

Water is often added to ease and improve the extraction process.

Two traditional methods of oil extraction are given here as examples:

Sunflower oil

1. grind the seeds to a paste. It is better to remove the seed coat if possible
2. the paste is heated, alone at first and then with water. The mixture is stirred and brought to the boil
3. after boiling the mixture is allowed to cool. The oil gathers at the top and is scooped off

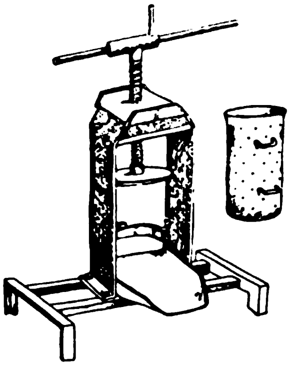
Crab oil

1. collect the seeds and boil them for two hours. Leave overnight.
2. crack open the seeds and remove the kernels.
3. squeeze several seed kernels together into a ball. The balls are called seed cakes.
4. place the ball onto a zinc sheet which is tilted and funneled so to collect the oil.
5. the seed cakes are left in the sun up to 2/3 days. During the evening the seed cakes should be taken inside.

These traditional methods of oil extraction, at best, only extract half of the oil found in the seeds. This means that the seed cake that is left still has a high oil content and can be used against insects. The seed cake could be incorporated in the soil or be soaked in water to produce an emulsifiable spray solution.

Special equipment would be needed to improve the rate of extraction. Below is a diagram of a hand-operated screw press, which when used appropriately can recover 90% of the oil. This type of machinery could be quite easily made in Guyana.

Figure 5.1 A hand-operated screw press



Oils are found in other parts of the plant but at lower concentrations. Plants such as lemon grass do not have recognised oil seeds but do have useful oils. With lemon grass, the roots contain the highest amounts of the oil. For these plants, oil extraction is a little more difficult and the quantities extracted are smaller.

5.26.4 Unprocessed plant parts

The use of neem leaves to protect stored grain is a good example of using plant parts against insects without any further processing. It is usually best if the plant part is dried. The moisture of fresh material may encourage the development of mould, which may spoil the stored product. A proviso to this is that it is only the fresh plant material which produces active volatiles, (gases produced by the plant), and these may be the way in which the plant prevents insect damage.

5.26.5 Growing the plant

The plant itself may be effectively used to solve a pest problem. Investigate whether the plant repels insects from a crop when planted in close proximity. Alternatively, insect pests may ignore crop plants in preference to a non-crop plant, which happens to be there, or which has been deliberately planted there, (i.e. a trap or sacrificial species). Observations of plants in their natural state are important here. Black sage (*Cordia curassavica*) normally dominates its immediate surroundings because it produces toxins against other plants. It is also an attractive plant to the black bees, which damage breadfruit, bora and banana. This is because the leaves produce a sticky substance that these bees seem to use for nest building. Now what do you know about the various plants around you? Have they any useful properties that can be used to your advantage?

5.27 Safety precautions

It is very important, when you decide to trial plants, that proper safety precautions are taken. For many of these preparations, long and short-term effects on humans are not known. Look again at the safety precautions mentioned in Chapter 4 on the correct management of insecticides. Follow and observe them. For those plants known medicinally or culturally, there will already be some idea of their safety to humans. As a rule if you don't know the human toxicity of the plant then treat it with the utmost caution.

5.28 Soap powder

The addition of soap powder is often used to enhance the role of botanical preparations. With small additions of soap powder the spreading and sticking ability of the botanical preparation over the plant and the target insect is improved. With higher amounts, the soap powder itself starts to kill insects. Aphids and small caterpillars are the first to die. Care must be taken with soaps because if too much is added, plants start to die. Also extensive use of soaps introduces unwanted phosphates into the water systems.

Table 5.2 - A simple guide for the use of soap powder.

Amount of soap used		**% of soap to water in a:**	
handful (man's)	millilitres (ml)	bucket (10L)	sprayer (20L)
½	25	0.3%	0.15%
1	50	0.6%	0.3%
1½	80	0.8%	0.4%
2	100	1.0%	0.5%
3	150	1.5%	0.8%
4	200	2.0%	1.0%

Note: soap has different effects at different concentrations:

below 0.4%	-	doesn't kill insects in itself but does improve the effectiveness of the botanical preparation.
0.5% - 0.7%	-	small, soft-bodied insects are killed by the soap powder.
0.8% - 0.9%	-	larger insects are killed.
1.0%+	-	damages the plants.

During your trials, when determining whether a botanical preparation is insecticidal or not, be careful when adding soap powder. You do not want the insecticidal effects of the preparation to be masked by the soap powder's effect.

5.29 Recording your work

It is important when testing plants with suspected insecticidal properties that everything is done methodically. Look at the following record sheet – it will give you an idea of how any work you do could be accurately recorded. Doing so will give you a useful body of information for future reference. If others collect information in the same way, then you start to get a database that can be shared, laying the foundation for future work and the development of botanical pesticides in Guyana.

Record sheet for botanical preparation trials

Name of plant

Local name: ***Scientific name:***

Habitat & distribution
(e.g. a savannah tree species found commonly in the Rupununi)

Growth requirements
(e.g. needs good rainfall during early growth but then conditions should be dry later if good seed production is required).

What other uses does this plant have, (e.g. medicinal, religious, food etc)
(e.g. the leaves are used for seasoning cooking)

Plant part chosen for the trial
(e.g. leaves)

Stage of development of plant part used in trial
(e.g. the young, pale green leaves)

Preparation method

Type of preparation: (e.g. hot water extraction)

Methodology: in this type of preparation, include such things as:

- quantities used, (give units) of plant part
- dried/fresh plant parts used
- preparation of plant part, (e.g. leaves bruised before being put into the water)
- the volume of water the plant parts were boiled in.
- the length of time taken to boil the plant part.
- final volume of the liquid. Any further water added?
- filtered or not

Further additions to the preparation
e.g. soap powder, (how much?), disinfectants, other botanical preparations.

Storage of preparation

***Storage container*:**

Storage conditions: (e.g. dark/light, cool/hot etc)

Length of time stored before use:

Pest targeted

Local name: ***Scientific name:***

Stage of pest's development targeted: (e.g. adult, newly emerged larva, pupae)

Type & frequency of application:
e.g. used a **full CP3** spray can, **(18L)** over a **3 acre** area. Sprayed **under** the leaves. Repeated this **once a week**, spraying in the **early morning**.

Crop treated and stage of growth:
e.g. young red pea crop.

Weather conditions during application
e.g. light rains and strong winds

Effect of preparation on pest

- did it kill the insect, stop it feeding, affect its behavior?
- how long did it take for the effects to occur?
- how long was the preparation effective for?

CHAPTER 6 UTILISING IPM AGAINST SOME INSECT PESTS IN GUYANA

In this chapter we look at five cases where the control of a pest is undertaken following IPM principles. Each case highlights certain aspects of the IPM process as well as giving practical advice for the control of these pests common to Guyana. The insect pests discussed are:

1. Sapodilla fruit fly ("worms in fruit")
2. Leaf miners ("Chinese writing")
3. Acoushi ants (leaf cutting ants)
4. Diamondback moth in cabbage
5. Paddy bug in rice

6.1 Possible measures to reduce Sapodilla fruit fly (*Anastrepha serpentina*) damage in sapodilla fruit (*Manilkara achras*). Pomeroon river region - Guyana

CASE #1 - "Worms in fruit"

Fruit fly pests worldwide pose a serious economic threat to agriculture. With 4-5000 fruit fly species worldwide, many fruit types are affected, including important fruits such as citrus, coffee, apples, mango, avocado, pear and many more. One species of fruit fly alone, the Mediterranean fruit fly (*Ceratitis capitata*), has over 260 host plant species.

6.1.1 Fruit fly biology

Figure 6.1 shows the four life stages (egg, larva, pupa and adult) of a fruit fly.

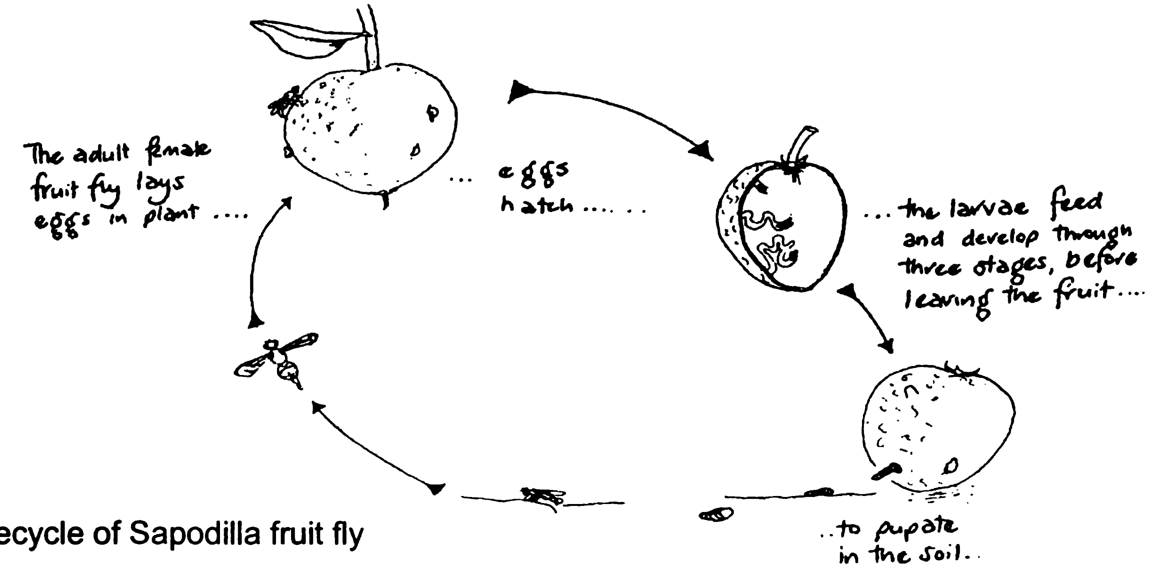


Fig. 6.1: Lifecycle of Sapodilla fruit fly

The life history and population dynamics of fruit flies make them very difficult to control. To be effective, control efforts have to incorporate the entire range of a local population which may extend over areas of country-sized proportions. Control measures are also very costly, Japan spent about US$32 million and used 200,000 man-days of work to eradicate one species of fruit fly from its south-western islands. Although expensive, the costs are still justified when compared to the potential economic losses of an established fruit fly population.

Guyana has a number of fruit fly species, some are local to this part of South America whilst others introduced species. The fruits most often found infested in Guyana are guava, sapodilla, star apple and whytee. People frequently open a sapodilla fruit to find a rotting mess inside and a couple of fat wriggling "worms". The Sapodilla fruit fly attacks mainly sapodilla (*Manilkara achras*) and star apple (*Chrysophyllum cainito*). Other common fruit fly species found in Guyana include the Guava fruit fly (*Anastrepha striata*), the most important fruit fly on guava (*Psidium guajava*) and the West Indian fruit fly, (*Anastrepha obliqua*), which is commonly found infesting hogplum (*Spondias mombin*). Presently the Carambola fruit fly, (*Bactrocera carambolae*) is threatening our borders with Suriname. It has a wide host range, exceeding 20 fruits, including sweet carambola (*Averrhoa carambola*), West Indian cherry (*Malpighia punicifolia*) and guava.

Damage to fruit occurs when the female fruit fly lays her eggs under the fruit surface. The larvae or "worms" hatch, feed in the fruit and, after a certain period of weight gain and development, leave the fruit to pupate in the soil. A fruit fly's life-cycle (Plate 6.1) can take between 3 weeks to one year to complete, depending on the fruit fly species and conditions. More usually it takes between 1-3 months. Most of that time is spent as an adult. Fruit flies have a high reproductive capacity - a female can lay as many as 1500 eggs over her lifetime.

Plate 6.1 - The larval, pupal and adult stages of the Sapodilla fruit fly

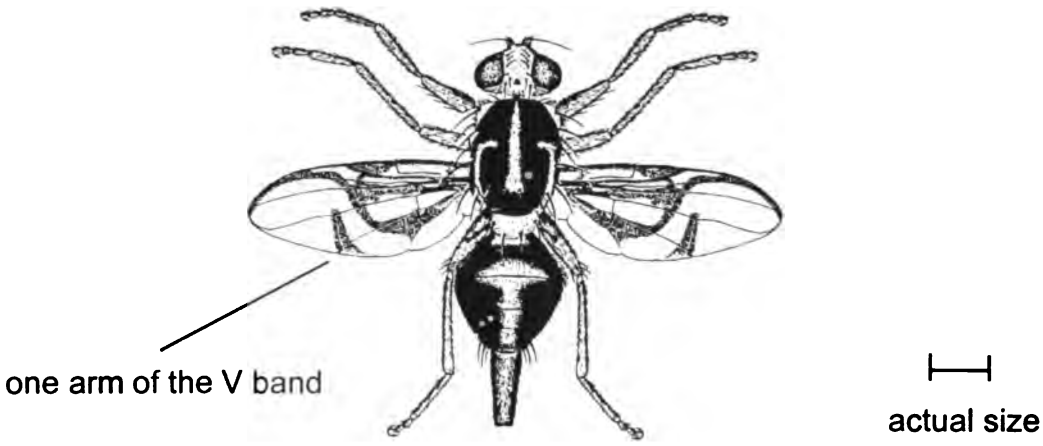
The Sapodilla fruit fly is a widespread pest of sapodilla in the Pomeroon river area, as it is in many other parts of Guyana. The Pomeroon has the reputation of being one of the most productive fruit-growing areas of the country. With sapodilla fruit selling for G$250-300 a dozen in Georgetown, it is a fruit crop with a high market value. When an area has sapodilla fruit fly, however, it is not uncommon for all the fruit on a Sapodilla tree to be infested with the larva of the fly, locally referred to as "worm". An infected fruit cannot be easily sold fresh and may only be used for jam-making, fruit juice or be thrown away.

Within the Pomeroon, little is done to reduce the incidence of the fly, largely because there is not a lot that can be done. There are certainly not enough resources in the area to finance and organise aerial spraying or widespread ground spraying. While complete eradication of the Sapodilla fruit fly in the Pomeroon area is almost impossible, local efforts can be made to reduce the number of flies present, thereby decreasing fruit damage and improving saleable yields.

6.1.2 **Fruit fly identification**

Below is a basic identification guide for three of the common species of fruit fly found in Guyana (Figure 6.2, 6.3, 6.4):

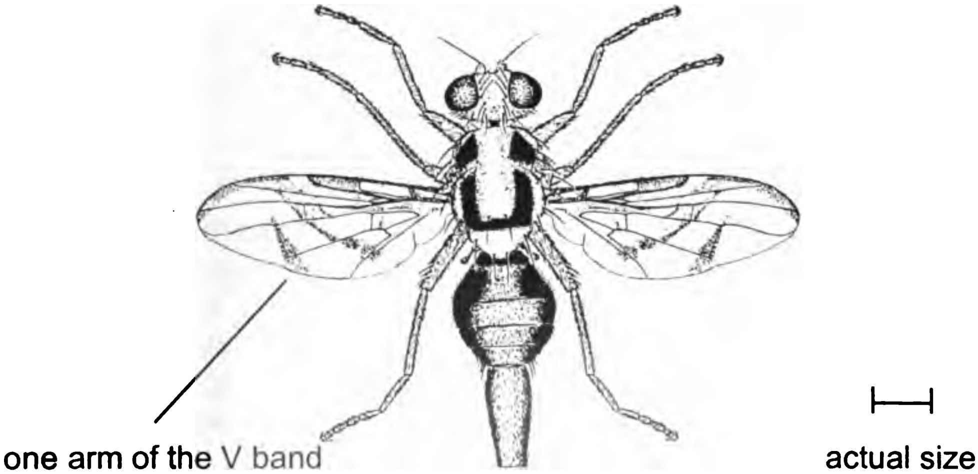
Figure 6.2 Sapodilla fruit fly (*Anastrepha serpentina*)



The Sapodilla fruit fly:

- is relatively dark in colour mainly on the thorax and abdomen;
- has black markings on a yellow background on the thorax and abdomen;
- has a distinct "T" on the abdomen;
- has only one arm of the V band present;
- has a relatively long ovipositor. The ovipositor extends out from the posterior end of the female insect and is used for piercing the fruit and egg-laying.

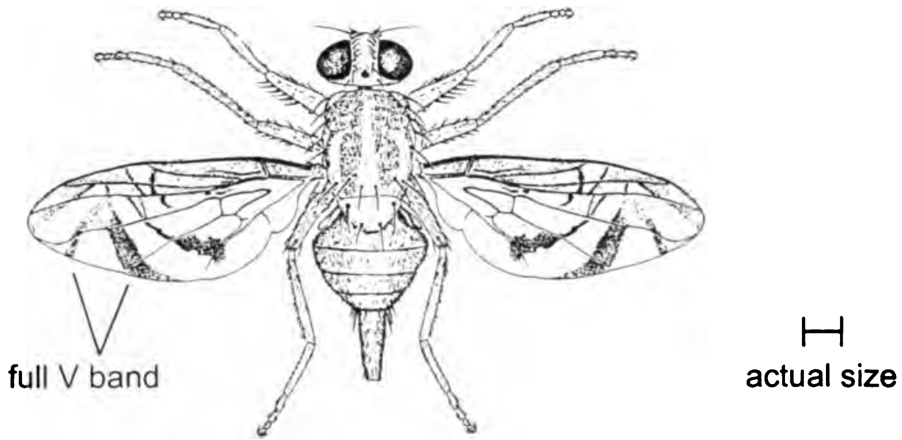
Figure 6.3 Guava fruit fly (*Anastrepha striata*)



The Guava fruit fly has:

- brown and black markings on a yellow background on thorax and abdomen;
- a distinct "U" shape on the thorax;
- has only one arm of the V-band present.

Figure 6.4 West Indian fruit fly (*Anastrepha obliqua*)



The West Indian fruit fly has:

- brown markings on a yellow background on thorax and abdomen;
- has two arms of the V band present.

6.1.3 Monitoring – the use of traps in a control program

Generally it is useful to set up a trapping system to monitor adult fly numbers. This allows the farmer to follow fluctuations in adult activity and determine periods of greatest egg laying. This information can be used in control decisions.

Fruit flies are attracted to the traps (using olfactory lures and other methods), killed by the bait and kept within the trap until it is visited and serviced. Lures which strongly attract males of the species (parapheromones) have been developed for some fruit fly groups but not for the group which includes the Sapodilla fruit fly (i.e. *Anastrepha* spp.). These have to be collected in non-specific traps that rely on an ammonia source as bait, or ones that combine visual and olfactory attraction. Such traps have to be placed in relatively high numbers (a rate of 45 traps per hectare has been used in one study) because they are only effective over a limited area, unlike the parapheromone-based traps. In these non-specific traps both sexes are attracted. Female flies are trapped in greater numbers since they need a high-protein diet to permit egg maturation.

Usually McPhail type traps (Plate 6.3) are used when fruit flies are trapped using an ammonia-based attractant. Torula yeast tablets, dissolved in water, make the most effective attractant in McPhail traps against the Sapodilla fruit fly. Unfortunately, neither the yeast tablets nor McPhail traps are available in Guyana. Frequently it is necessary to “Guyanise”. Homemade traps can be made with plastic water bottles that have had their neck cut and inverted and then painted yellow (a colour often found attractive to insects) - see Plate 6.2.

Plate 6.2 - Homemade fruit fly trap

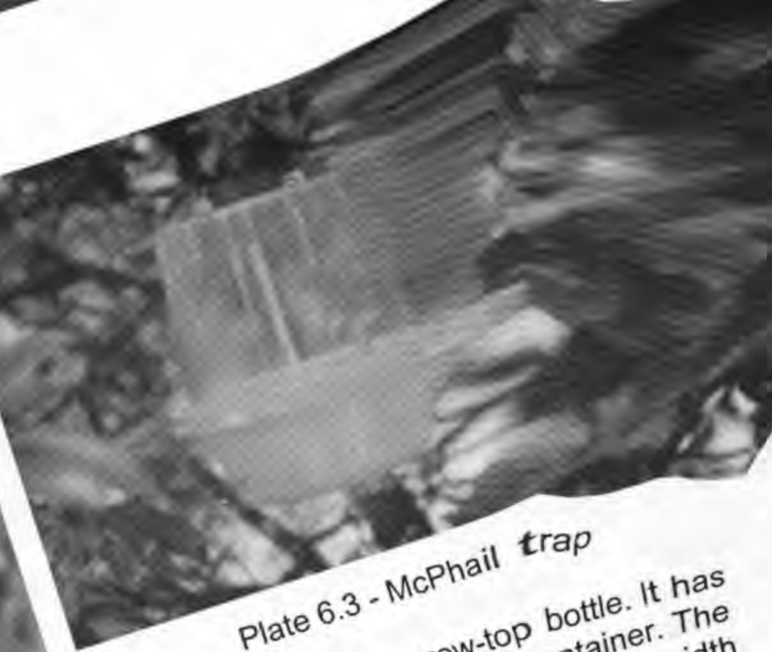


Plate 6.3 - McPhail trap

Another homemade trap design (Figure 6.5) is made from a plastic, screw-top bottle. It has two finger-sized holes, about 3" high from the bottom, cut into the sides of the container. The trap is suspended by drilling a hole in the centre of the cap and then pushing a double-width piece of string through, before knotting it on the inside.

A liquid attractant recommended for this design is:
- 1 cup of vinegar
- 2 cups of water
- 1 tablespoon of honey

Figure 6.5 - Homemade fruit fly trap made from a plastic bottle.

These ingredients need to be shaken well and the bottle filled to 2" below the finger holes. Once the flies "smell" the attractant they will investigate its source, which in time will lead them to enter the bottle through the cut holes in the side. Once in, they will find it very difficult to escape and most will end up drowning in the liquid attractant.

For trapping work in the Pomeroon, the following recipe was used to make a successful Sapodilla fruit fly attractant:

2 litres water (9 cups)
1½ tablespoon of vanilla essence (20mls)
1 green sapodilla - grated
2 tablespoons of honey (30mls).
1 cup urine

This recipe is derived from one found in Gaby Stoll's book called "Natural Crop Protection". The grated sapodilla and honey are probably not crucial to the success of the attractant. These homemade attractants can be experimented with to produce the best results. Usually a bait/attractant needs to be aromatic with a sweet and ammonia-based smell. They may not be as attractive as those sold specifically as fruit fly baits (e.g. torula yeast tablets) but that is not important. The traps are used to detect changes in fruit fly numbers. Therefore we are looking for **relative** and not **absolute** fruit fly numbers. This also holds true for homemade traps, they don't need to catch every fly in an orchard but they do need to pick up the increase in fruit fly numbers when flushes occur in the fruit fly population.

If you are interested in identifying the fruit fly species caught in the traps it would be best to service the traps once a week because insects left any longer will start to break down.

6.1.4 Monitoring – detection of egg-laying activity

There is an alternative to trapping when detecting egg-laying activities in sapodilla. Sapodilla is a fruit that bleeds a white latex substance when damaged. This bleeding occurs in fruit that are not yet fully ripe. When fruit flies lay their eggs, they damage the fruit and characteristic white dots are left on the surface of the fruit. Plates 6.4, 6.5 & 6.6 show the characteristic puncture marks and early fruit fly damage. Other types of damage to the fruit leave different types of white marks. From field observations it was observed that the main fruit fly egg-laying activity is primarily linked to a particular stage of fruit development rather than weather or other conditions. This particular stage of development corresponds to the peak period for new puncture marks and to the peaks of fruit fly numbers caught in the traps.

Plates 6.4 & 6.5 - Characteristic white dots representing fruit fly egg-laying activities

Plate 6.6 - Beginning of fruit fly damage originating from white dot

6.1.5 Control measures

Timing the control activity

Control measures should be directed towards specific stages within a fruit fly's life-cycle. Depending on the stage of the life-cycle, certain measures will be effective while others will not. For example, a particularly vulnerable stage for the fruit fly is when the fully developed larva leaves the fruit to pupate in the soil, (**larval emergence**). It makes easy prey for other insects and birds. It is important to know the pest's biology to best determine which stage of the pest's life-cycle would give the greatest decrease in crop damage, if controlled.

> A control strategy is not just about killing as many insects as you can. Ultimately a successful crop protection activity is about stopping or preventing crop damage.

Under present conditions in the Pomeroon (and many other areas), reducing fruit damage is best achieved by controlling the adult fly when it is about to start laying. Targeting the pest at larval emergence would have minimum benefit in the Pomeroon. Why? Because although an individual farmer may kill most of the larvae leaving the fruit, the damage to the fruit for that season has already been done. Worse still, when the next fruiting season starts, fruit flies will again re-enter his farm from surrounding farms. This is bcause fruit flies have the capacity to travel long distances and spread easily into new areas. This spread of fruit fly is especially easy in the Pomeroon where farms are close together and most have sapodilla trees. So although generally control of fruit flies at larval emergence may be less expensive, less wasteful and less time-consuming, for the Pomeroon farmer, it would not be very effective. Thus control of the adult prior to egg-laying is considered the most effective option. This would remain so until all the farmers in the area could be organised to jointly target the emerging larvae, thus reducing fruit fly numbers over the whole fruit fly range.

The control of the adult fruit flies before and during the egg-laying period allows the farmer to protect his fruit without having to rely on others. Of course, he is still affected by the huge number of flies on neighbouring farms. (Fewer flies within the total population range would mean fewer flies around his individual trees). There are problems with trying to control the adults and it is very difficult to get the desired reduction in fruit damage. Even if a farmer kills 99% of the flies, there will still be a few adult females present. If they survive and lay their 1000+ eggs, he still has a problem. An additional problem is that the methods used to control adults are quite expensive and time-consuming.

The discussion above shows that the number of pests killed during a particular pest control event is not the measure by which the success of a control strategy should be judged. Killing off all the pests now doesn't mean that later on, there will not be a high pest population, or high levels of fruit damage.

Success primarily depends on:

a) **a sustained decrease in numbers of insects**;
b) **a reduction of damage throughout the life of the crop**; and
c) **a reduction of the costs associated with the pest problem, (man-hours, money, resources, environmental damage).**

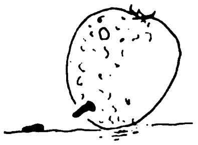
It is important to consider carefully the insect's vulnerability to various control options; the chance of a particular control event being a long term success; and the costs required to achieve long term control.

With this in mind, let's look at the control options.

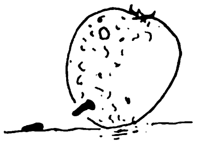
Before larval emergence:

early picking of fruit - a method presently used by farmers to avoid the economic losses of spoilt fruit is early picking of the fruit. Fruit fly larvae in prematurely picked fruit (i.e. those picked before reaching the "full" stage) cease to develop and so die. When the fruits are picked at this stage, the larvae are too small to be seen and the damage they have done is not noticeable. If the consumer does not notice, then everybody is happy. Well, not entirely. The problem with these fruit is that they end up small and not very juicy or tasty. This is because the fruit can't develop properly once picked premature. There is a trade-off.

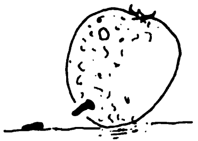
At larval emergence:



destroying fallen fruit - one simple but time-consuming way to reduce fruit fly numbers is to regularly pick up fallen fruit and dispose of them so that the larvae inside are killed. This is best done by throwing the fruit in the river or trench. Do this regularly, if fruit are not picked up soon after they fall, the larvae will escape into the soil. Stripping the trees of fruit and destroying them is an extreme but effective method of killing fruit fly larvae.



weeding the base of the tree - keeping the bottom of the trees weeded clean is useful as it increases the chance that the larvae leaving the fruit are predated by birds, ants or other ground insects.

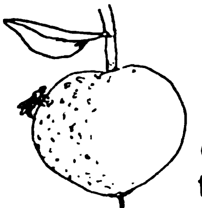


spraying the base of the fruit tree with a soil chemical - a measure which may be useful is the spraying of a soil insecticide such as "Basudin" (Diazinon) at a time when the fruit is dropping and larvae moving into the soil. This may not be financially possible if there is an extended period of fruit drop, or if there are a large number of trees to spray. The insecticide would also reduce the number of beneficial insects which naturally predate on the larvae.

Before and during egg laying:

Targeting control efforts against the fruit fly adults around the egg laying period has been identified as a better option for individual Pomeroon farmers. Adult fruit fly activity at this time is focussed around the sapodilla trees as they feed, mate and prepare for egg-laying. There will be an increase in numbers of fruit flies caught in any traps hung during this time. Information from traps should be used to time control efforts.

broadcast spraying of the sapodilla trees at periods of adult fruit fly flushes, with an insecticide such as Malathion may provide some protection, but it is an expensive control option. Broadcast spraying is when the whole tree is sprayed with the insecticide. The costs associated with this method are high, partly because the sapodilla tree produces new fruit throughout the fruiting season thereby extending the required spraying period. Trapping work in the Pomeroon, however, indicates that there is a distinct flush of around 4 to 6 weeks' duration, where very large numbers of flies are caught in traps. This would then be the period to initiate the broadcast spraying. Choice of insecticide is very important. Of prime concern is the possibility of pesticide residues in fruit. For its relatively low toxicity, Malathion is usually recommended.



bait spraying - this is probably the best method of controlling adult fruit flies in Guyana. Bait sprays work on the principle that both male and female fruit flies are strongly attracted to a protein source from which an ammonia smell emanates. The protein source/attractant is mixed with an insecticide to make the bait. Bait sprays have the advantage over broadcast sprays in that they can be applied as a spot treatment to specific parts of the tree (Figure 6.6). The fly goes to the insecticide, rather than the other way round. Experience has shown that spraying areas of the foliage works best. In addition to saving costs, this method also reduces the negative impact of insecticide on natural predators.

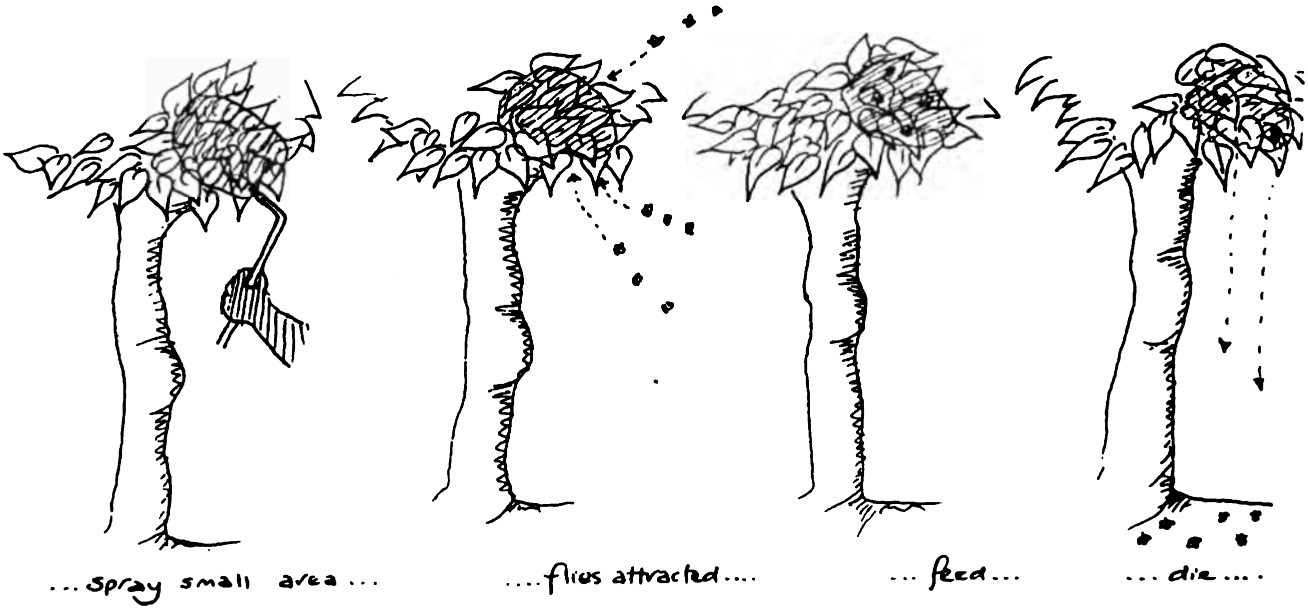


Figure 6.6 Bait spraying method

There are various attractants which can be used as baits in bait spraying, the principal types being hydrolysed protein and autolysed yeast. A possible local source of yeast, which could be used in an attractant preparation, is brewery waste. Its availability in Guyana needs to be established. Successful trials of a bait spray consisting of brewery waste, (pH raised from 4 to almost 7), Malathion and a sticking agent have been carried out in Malaysia by Queensland Department of Primary Industries.

Together with the attractant used in the bait spray, an insecticide is needed. Malathion is normally used at 10g (active ingredient; a.i.) to a litre of spray solution. To keep the bait spray on the tree for as long as possible, a "sticker" is required. Vegetable oils (e.g. coconut oil) make good homemade stickers. Homemade attractants or lures can be made quite easily (recipes for two are mentioned later). Below are a few points for a successful bait spraying exercise

a) make sure the spray solution is well mixed before spraying, (it needs to remain emulsified);
b) spray a grid of bait spots at between 5-10 metre intervals, (16-32 ft), in the orchard. Each spray spot, about 100ml, (3.4oz), should be delivered as a solid jet, rather than a dispersed spray; and
c) the treatment should be carried out at regular intervals throughout the active season. Typically, every week at time of peak activity.

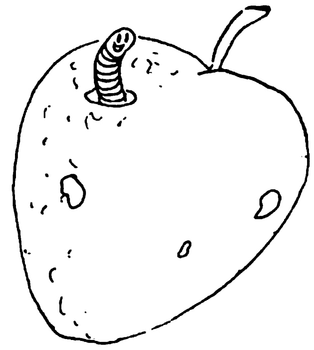
If this control method can be developed in Guyana, it could become a viable way of reducing fruit fly damage to fruit crops.

6.1.6 **Further control issues**

Because of the large number of fruit one sapodilla tree can bear, the possibility of protecting the fruit by wrapping them in bags is expensive, although viable.

Further work aimed at developing control options should investigate the phenomenon whereby certain Sapodilla trees have never been infested, even though they grow in orchards infested with sapodilla fruit fly. Then there are the trees that are only sometimes infested while others around are always infested. What are the characteristics that confer these differences? Perhaps there is a difference in the odour of the fruit. Farmers and scientists, when asked about this, had no answer to explain the phenomenon - do you? People also mention that longer sapodilla fruit are more likely to be infested with fruit fly than those that are more round. This also should be investigated. In conclusion, it becomes obvious that while there are many practices which can be introduced to monitor and control fruit fly populations, there is still much to be learnt.

6.1.7 **Fact sheet**



CONTROL OF FRUIT FLY PESTS IN GUYANA

Biology:

- fruit fly lay eggs into fruit and these hatch to become the "worms" you find in fruit.
- guava, sapodilla, star apple and whytee are fruit which are commonly infested by fruit fly.
- the three most common fruit fly species in Guyana are:

  Guava fruit fly, (*Anastrepha striata*)
  Sapodilla fruit fly, (*Anastrepha serpentina*)
  West Indian fruit fly, (*Anastrepha obliqua*)

- a fruit fly species presently posing a threat to Guyana is the Carambola fruit fly, (*Bactrocera carambolae*)

Control:

- fruit flies are difficult to control because the control efforts have to incorporate the whole range of a local fruit fly population. These populations can be spread over very large areas.The three main fruit fly species mentioned above are found throughout Guyana.
- the timing of a control effort is crucial. Information on fruit fly biology and population dynamics allows you to control the stage of the fruit fly's development which gives the greatest long-term drop in fruit fly numbers and damage to the fruit.
- two development stages normally targeted by control efforts are **larval emergence** from the fruit and **adults before laying**.
- unless the control action is going to be conducted over a wide area, or on a farm isolated from surrounding fruit flies, it is best for the individual farmer to try to control the adults before laying.
- **Malathion** is the most commonly used insecticide in fruit fly control measures.
- it is worth developing **fruit fly attractants** to use in **bait sprays**. With bait sprays you don't have to spray the whole tree or orchard. The fruit fly will come to the bait spray patches, (an attractant/insecticide mix), which you have sprayed onto the trees.
- **traps** are very useful for fruit fly control strategies. Homemade traps can be made out of plastic bottles. Homemade attractants to put in the traps can also be made. The attractant should have an ammonia smell, (you could use urine), and a sweet smell, (you could use the fruit, vanilla essence or honey).
- traps can tell you when large numbers of adults are around so that you can implement your control action before they start laying eggs.
- characteristic white latex dots on the skin of half ripe sapodilla fruit is evidence of fruit fly egg-laying.
- there is a peak period of egg laying as defined by trap counts and increase in the white dots. This peak egg-laying period is related to the stage of fruit development primarily. Weather is also important.

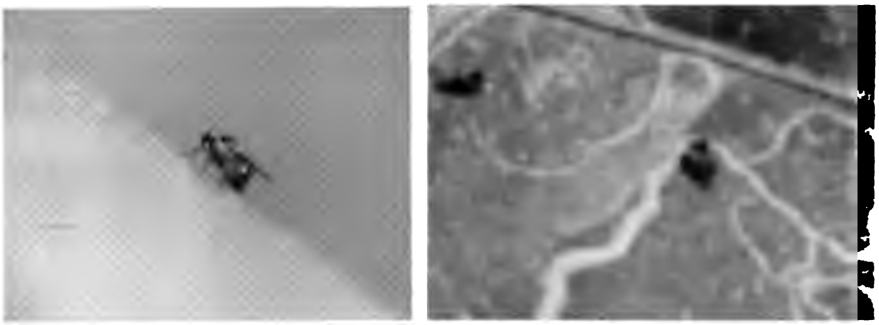
6.2 Notes on leafminer biology, present control problems and possible solutions for Guyana

CASE #2 – "Chinese writing"

Evidence of leafminer activity, ("Chinese writing"), is widespread in many plants and is not just restricted to agricultural crops.

6.2.1. **Leafminer biology**

Plates 6.7, 6.8 & 6.9 and the Leafminer's life cycle (Figure 6.7) show the typical patterning (leaf tunneling) caused by Leafminers on some of our crops (in this case red pea). Leaf tunneling can be caused by larvae of a number of insect families. There are families in the fly, moth and beetle orders, which have leafmining species. The larvae of the small Agromyzidae flies cause most of the leaf tunneling we see on red pea plants here in Guyana. These flies are small black to grey with yellow markings.



Plates 6.7 & 6.8 - Adult Leafminer flies feeding and laying eggs on red pea leaves.

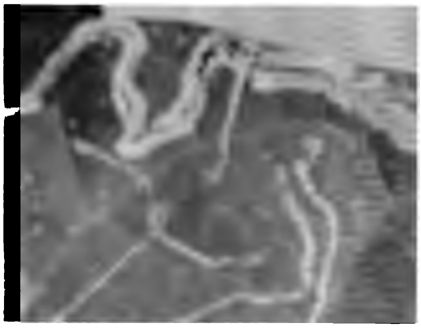


Plate 6.9 - Leafminer larvae feeding at the end of their mines.

What we see on the leaf is the pattern caused by the larvae that live and feed in between the upper and lower surfaces of the leaf. The larvae effectively make tunnels within the leaf (these tunnels are called mines). When the larvae are in the mine, they are usually found at the broadest end of the mine. The larvae are a pale yellow/green in colour. On close examination of the leaf, one may find many small dots on the leaf surface. These represent the feeding and egg-laying holes of the adult insect.

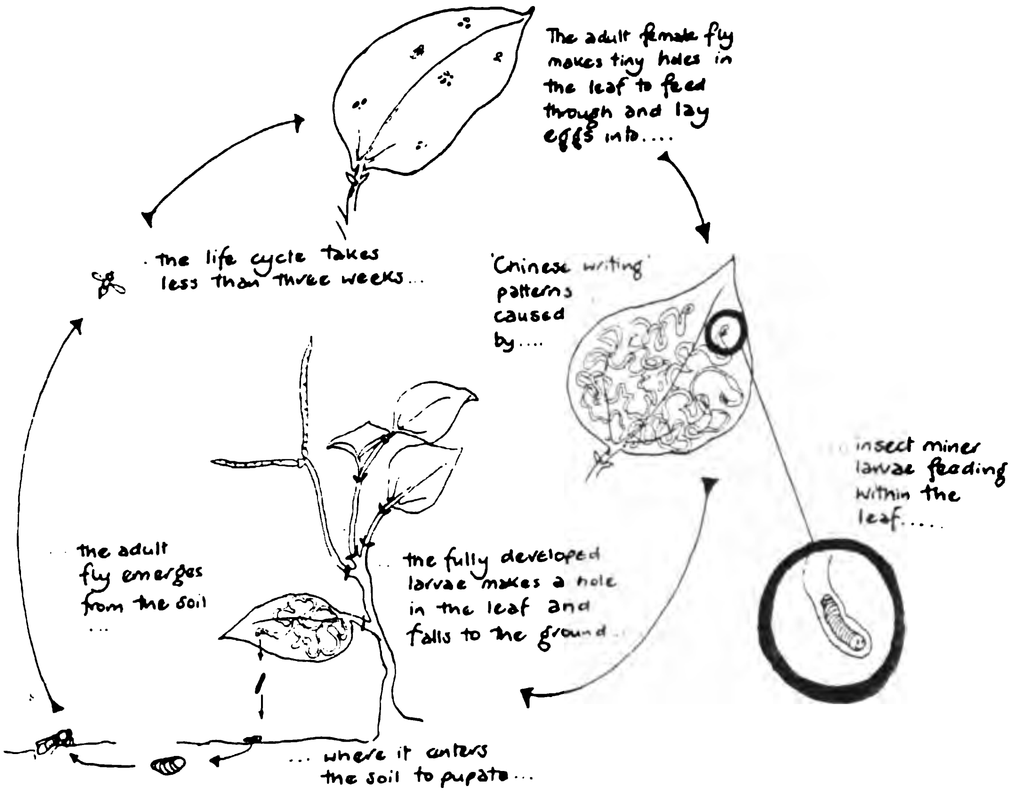


Figure 6.7 The Leafminer life cycle

Many generations occur each year and the entire life-cycle can be completed in less than 3 weeks. The larvae feed for about 1-2 weeks before leaving the leaf to pupate, usually in the soil. Pupation lasts for around 10 days. Most evidence of Leafminer activity is seen in the dry season.

Real damage is done to the plant when individual leaves are mined by a number of larvae. It can reach a stage where there are more mines than green leaf. Complete leaf drop and plant death can be the outcome of severe infestations. It is interesting to note that these levels of Leafminer infestations are not found in farming systems that use minimal insecticides. These severe outbreaks are good examples of when a heavy insecticide regime worsens a pest problem.

Under natural conditions, Leafminers in crops other than foliage crops (i.e. those crops like celery where the harvested parts of the crop are the leaves themselves), do not pose a great threat to the yield of the crop. Leafminer activity results in the removal of some of the chlorophyll (the green stuff) from the leaves, which reduces the leaf's capacity to turn the sun's energy into food for the plant (i.e. decreasing its photosynthetic capacity). When the Leafminer infestation is not extreme, the decrease in photosynthetic capacity is compensated for by the plant and there is no discernible reduction in yield.

In Chapter One, where we dealt with Integrated Pest Management (IPM), Leafminers were given as an example of a pest that looks worse than it really is. It does look a mess but usually it doesn't warrant action. If, for whatever reason, the farmer decides that the Leafminer is a pest and it needs to be controlled, then some relevant issues need to be considered. These are briefly discussed below.

6.2.2 **Possible non-chemical control options**

Here we discuss some of the non-chemical control options we have available to us. In particular we highlight the role of the natural predators and parasites in the maintenance of low pest levels.

A. Natural enemies of Leafminers

Let us examine the role of natural enemies. Field observations in Guyana show that there is definitely predation and parasitism of Leafminer larvae.

i. Ants are the most visible of predators against this pest. In addition to predating the emerged larvae in the soil, prior to pupation, they also attack the larvae feeding in the leaf. This they do by plucking the larvae out of their mines. The evidence of this is a rough-edged, larva-sized hole, above the end of the mine where the larva was found by the ant (plate 6.10).

Plate 6.10 – The hole at the end of the mine is evidence of ant predation of a Leafminer larva

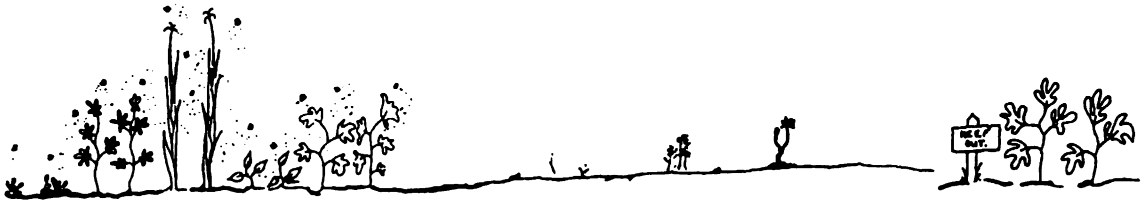
ii. Wasps are the most important natural enemies of leafminers. The most important wasp parasites are in the families Chalcidae and Braconidae. These insects lay their eggs into/on/near to the larvae, through the leaf surface. Wasp larvae then feed and develop on the Leafminer larvae before pupating and becoming adults. Visual evidence of chalcid wasp parasitism is a brown smudge of the dead larvae in the tunnel and a neat, circular hole in the leaf's surface, above the larva. This circular hole is where the new adult wasp has emerged.

These beneficial insects are particularly susceptible to insecticides because of their behaviour. As predators or parasites they need to find the pest they're preying on. To do this they normally apply an intensive search behaviour that takes them over much of the plant surface. In doing so, they repeatedly expose themselves to any insecticide that is on the plant. Thus, these insects are the first to be killed.

What happens if the natural enemies are not keeping the Leafminer numbers below your thresholds? What do you do next?

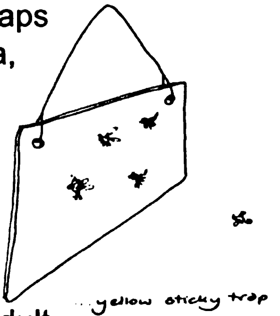
B. Cultural control

In terms of cultural control, the pest *Liriomyza trifolii* is found to attack a wide variety of vegetable crops. Having a number of alternative hosts is a problem - it seems there's always a host plant close by with leafminers and they're just waiting to infest your crop. It also doesn't matter that the plant they're on is different to your crop plant. Having a wide range of alternative host plants means that it is possible for leafminers to exist on a farm throughout the year without dropping in numbers. Try and grow your crop away from an area where other vegetables or plants are already suffering from leafminer attack.



C. Physical control

One physical means of lowering Leafminer numbers is the use of traps. At the International Potato Centre in Lima, Peru, trials were run, testing yellow sticky traps, (30cm x 30cm), placed at 60cm above the ground. From the results, it was found that the use of traps reduced the individual mine counts per plant from 9 mines to 2 mines. In Guyana, thin plywood, metal or plastic could be painted with a yellow paint (you should experiment with different shades of yellow) and coated with a thick grease. Following rains the grease may have to be reapplied. During the wet season, leafminers are not normally a problem and so traps won't be necessary.

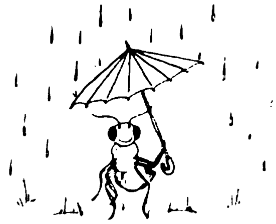


Sampling techniques for Leafminers can assist in the proper timing of control exercises. Traps can be used for general monitoring - to pick up the flushes in adult numbers. In the USA, another method of sampling used is where trays are placed between rows, under the foliage, to catch the pupae which are falling from the plant to pupate. This method works best indoors where ground predators are not present to remove the larvae in the trays. A pupal count will give you an idea of the infestation level. Mine counts in leaves can also work if there are not too many mines per leaf.

D. Botanical pesticides

One of the main objectives of this book is to offer the use of botanical pesticides as a valid control option within an IPM strategy. Experiences, in Guyana show that, there is definitely a role for biopesticides in controlling Leafminers. Experiments were conducted in red pea crops to trial local "biopesticides" against Leafminers. A preparation extracted from **quassia** wood (*Quassia amara*) gave good results (better than malathion, a contact insecticide), whilst **hot pepper** (*Capsicum frutescens*) also had a noticeable effect (see Chapter 5 for details on these botanical preparations). Quassia is reputed to have systemic properties, which is probably why it was effective against Leafminer. It is also not supposed to kill ladybirds (predator of many insect pests) and honey bees (amongst other things, pollinators). In control recommendations given in the USA for control of Leafminer in celery, a product called Neemix is suggested. The active ingredient in Neemix is Azardirachtin, one of the number of anti-insect chemicals found naturally in the neem tree. These compounds are found in all parts of the **neem tree** but at higher levels in the seeds.

In the literature, **tobacco** is also cited as being effective against Leafminers. In our trials, tobacco did not offer any significant control to the pest. However it should be noted that only one concentration and one methodology (i.e. 1 cigarette soaked in 6 litres of soapy water for 7 hours) were used. Tobacco may prove very effective against this pest if used in another way. There are other plants with mentioned insecticidal properties, which have yet to be tried against leafminers in Guyana - this needs to be done. When doing so, the effect of the biopesticide on the natural enemies should be monitored.



6.2.3 Chemical control strategies and considerations

A. The use of insecticides

Insecticidal control is the option which usually first comes to mind. Managed properly, this is an effective option. The main thing to remember when choosing the insecticide is that the larvae are, for the most part, protected within the leaf. Thus, contact insecticides, such as Karate, would be washed off the leaf without ever touching the insect inside. These contact insecticides may have an effect (they kill some of the adult flies walking over the leaf), but in terms of efficiency, they are not the best option. Systemic and translaminar insecticides are the better choice.

- **Systemic** insecticides are absorbed and moved around within the plant.
- **Translaminar** insecticides work by contact but are able to penetrate the leaf surface to get to the insect below.

Unfortunately the main systemic insecticide used in Guyana is Monocrotophos, which definitely is not recommended. It is one of the most toxic insecticides around and is suspected of having a long residual period within the crop. It cannot be sprayed within 2 weeks of harvest. Another example of a systemic insecticide being sold in Guyana is Trigard (*Cryomazine*).

When using insecticides, one should always be aware of the concept of thresholds. For leafminers in non-foliage crops, the thresholds are set high (i.e. a relatively high number of insect pests are tolerated in the crop before any action is taken). With high thresholds, it is a matter of carefully observing pest levels and environmental conditions whilst promoting natural predator and parasite activity. Chemical control is used as a last resort. Look again at the photographs of the adult leafminer flies (plates 6.7 & 6.8). They are small but once you recognise them, they are easily identified. Look for them and see if there are many walking around your plants. Identifying the adults and evidence of their activity (i.e. early mines and the presence of tiny feeding/egg-laying holes on the leaf [plate 6.11]) will give you an idea of when to act.

Plate 6.11 - Tiny feeding and egg-laying holes of Leafminer adults in red pea leaf

If insecticides are used, then the following should be observed:

- choose the right insecticide - one that can reach the larvae inside the leaf, (i.e. systemic/translaminar);
- be aware that by using insecticides you will most probably be killing all the natural enemies of leafminers - were they a big influence to begin with? Choose insecticides which, when left on the leaf surface, degrade quickly;
- be aware that leafminers have a history of becoming resistant to insecticides; and
- protect and manage the viability of effective insecticides against resistance. Rotate their use with other insecticides and minimise the number of times you use them during a season.

B. Leafminer resistance to insecticides

It is useful here to briefly discuss the phenomenon of Leafminers becoming resistant to insecticides. Resistance to an insecticide is said to have occurred when a consistently effective insecticide becomes ineffective and remains so over a number of seasons. Have you ever had an experience whereby an insecticide which you know works, has stopped working even though you are using it in the same way and on the same pest as before?

In Florida, USA, farmers began to experience problems of resistance back in 1974. Most of the spraying of insecticides was directed at leafminers in celery and tomato crops. Since 1974, leafminers have become resistant to many of the registered insecticides, so much so that the few insecticides that still work now have to be used very carefully to prevent or delay the onset of resistance.

Identified factors contributing to resistance are:

- **frequent applications of a single insecticide,** and
- **year-round cultivation in a relatively small area, isolated from similar farming systems.**

It is now recognised that as a class, the **pyrethroid insecticides** (see Appendix 1) have the highest susceptibility to insect resistance. They are very effective at killing insects which increases the selection pressure of resistance against insecticides. When pyrethroids are used, it doesn't take long before the only insects left alive and capable of reproducing are those, which have particular characteristics, making them non-susceptible to the insecticide. These then quickly become dominant in an isolated population of pests and their population grows to even greater pest levels, unaffected by the spraying regime.

As seen in Appendix 1, insecticides can be grouped into different classes (e.g. pyrethroids, organophosphates, carbamates). They are grouped by their similarities of chemistry, mode of action and the like. These similarities, found within a class, also extend to the ease in which resistance against them is acquired.

If you are using an insecticide that has worked against leafminer in the past but now doesn't, then resistance should be suspected. Methods of conserving effective insecticides and the pest types, which are often associated with resistant outbreaks are discussed in Chapter 4.

C. Detrimental role of insecticides on natural enemies

A red pea crop on the Essequibo Coast, in early 1997, gave a good illustration of how insecticides and natural enemies do not mix and how pest control measures can sometimes worsen a pest situation:

A chemical misadventure

A prolonged rainy season came to an end in February 1997 and after a few weeks, during the dry weather, high levels of leafminer damage were observed in Dartmouth. This damage quickly became severe, leading to total leaf drop and plant death in some instances. Some measure of control was gained through the use of Monocrotophos. Prior to the leafminer infestation and throughout the growth of the crop, insecticides were frequently used, largely as a response to aphid populations within the fields. These measures were precautionary - aphid numbers had never been at pest threshold levels. The decision to spray was more a response to the memories of how large these aphid populations could become, rather than as a response to present aphid numbers. By the time the leafminers became a problem, all their natural enemies had been wiped out by the insecticidal regime. On inspection, no predator/parasite activity was detected. Apart from monocrotophos, all the chemicals used against the leafminer on this crop were contact insecticides and had little effect on the larvae within the leaf. In fact, without natural enemies, the infestation just kept growing.

Weeks later, after much of the harvesting had been completed, and at a time when spraying of the red pea crop with insecticides had ceased, the crop was again examined. The leafminer populations had dropped considerably and there was evidence of renewed predator and parasite activity – the land had been "insecticide-free" for a few weeks now. As a result of the re-establishment of natural control over the leafminers, the number of mines per leaf was at a level that resulted in minimal yield loss. In other words, the leafminers were no longer a problem.

This example provides a number of lessons:

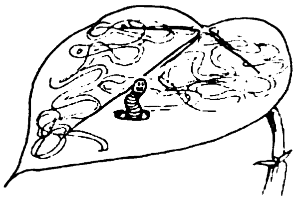
- **the role of natural enemies**;
- **insecticide use destroying important natural enemies**; and
- **choice of an inappropriate control measure that worsens a pest problem.**

There was even a suggestion that insecticide resistance had a role in the levels of leafminer observed in Dartmouth. This was however never confirmed.

6.2.4 Conclusion

Control of Leafminer pests is an interesting pest problem in that fine judgement is required to balance the different considerations of a control strategy. There are some viable control alternatives to synthetic insecticides and there is a strong argument for not interfering with the system at all - leave it to the natural predators. Pesticides can easily make a pest *situation* worse. Basically it is a pest situation where close observations of the pest, the crop *and the* natural enemies is essential for carrying out the right control strategy.

6.2.5 **Fact sheet**



CONTROL OF LEAFMINER PESTS IN GUYANA

Biology:

- Leafminers are tiny flies which start as small larvae ("worms") in leaves. These larvae eat the insides of leaves causing patterning which is locally called "chinese writing".
- Leafminers are mainly a problem during the dry season on crops like red pea, black-eye bean, celery, bora, tomatoes and many more.
- Leafminers have short lifespans of around 3 weeks and can, under particular circumstances of control mismanagement, become a very big problem, especially to young plants.

Control:

- This insect is a pest which looks worse than it is. Much of that untidy "chinese writing" you see on the leaves does little damage to the crop. In foliage crops like celery, however, the mines are a problem - they are ruining the very thing you're trying to sell, the leaves.

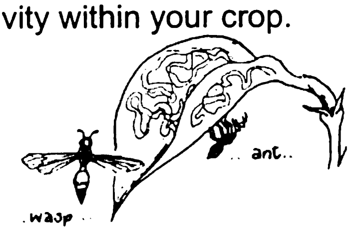
* *reasons for chronic levels of Leafminer infestations*:

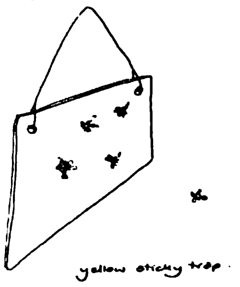
- wrong choice of insecticides (you need to choose an insecticide which gets into the leaf to kill the larvae);
- natural pests and parasites of Leafminer (ants and tiny wasps) are killed by the insecticides; and
- Leafminers become resistant to the insecticide being used.

* *control options*:

- do nothing. If no insecticides are around then the natural predators and parasites will normally keep Leafminer numbers down to levels which don't damage the crop;
- use appropriate insecticides and take precautions against resistance;
- botanical pesticides like quassia and hot pepper kill Leafminers. Quassia doesn't kill the natural enemies of Leafminer. Soak 250g of quassia stick in 5 litres of water overnight, throw in half a handful of soap, mix and spray the affected plants. Spray around the base of the plants as well as the leaves;
- don't plant near other crops or plants which suffer from Leafminer; and
- use yellow sticky traps to catch the adults for monitoring purposes.

Use traps, trays and mine counts on leaves to detect changes in leafminer numbers and activity within your crop.





6.3 Notes on leafcutting ant control in Guyana

CASE #3 - "Acoushi ants"

6.3.1 Introduction

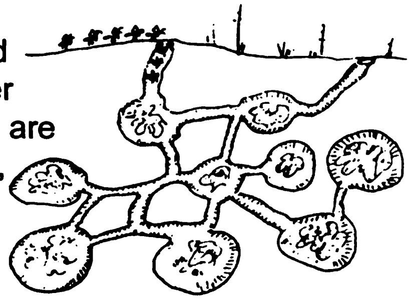
Acoushi ants is the local name given to those ants which are more widely recognised as the leaf-cutting or umbrella ants (Family: Formicidae, subfamily: Myrmicinae). In a study of the distribution and status of leaf-cutting ants in Guyana, (Munroe & Baker, 1993), it was found that *Atta cephalotes* and *Atta sexdens* were the two most important agricultural species. The former is found along the river banks and along the coast, while the latter is mainly found in the savannah and other sandy regions.

The acoushi ant species, *Atta cephalotes*, principally attacks trees (e.g. citrus) and shrubs (e.g. peanuts), rather than herbs (e.g. celery).

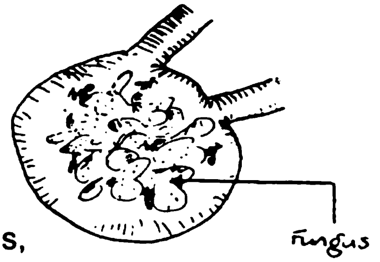
6.3.2 Biology of the leaf-cutting ants

Large numbers of people in the farming sector of Guyana personally feel the devastation caused by this pest. Because of their behaviour and social organisation they are a difficult pest to control. The main points of their biology in terms of pest management are as follows:

i. They live underground in large, intricate nests comprised of chambers joined together by a network of tunnels. Nests of over 100ft x 60ft have been found in Guyana and there is no doubt there are others even larger. If disturbed, the nest remains dormant for a while, until the danger has gone, whereupon the nest reactivates itself. This can be after a few weeks or a number of months.



ii. They are termed social insects in that their tasks within the colony are shared. The reproductive queen remains underground and is fed and protected by others. She alone produces the young, so even if all ants above ground are killed, more ants will be produced by her as needed. On the other hand, if the queen of a nest is killed, the whole nest is effectively destroyed.



iii. These ants only eat fungus, which they grow in the nest, using leaves and other material that they collect. This fungus is the whitish-brown, soft, spongy material found in the large cavities of the acoushi ant nests. Inside the fungus are found lots of white eggs and developing ants, which are surrounded by many tiny adult ants, which tend and protect them, (see plates 6.12 and 6.13). The fungus gardens, in effect, are biological filters against the toxins, tannins and other unpalatable products found in the plant material brought into the nest. For this reason, almost all plant species can be attacked. Only plants, which produce sticky latex when cut, manage to deter acoushi ants through purely physical means. Because domesticated crops have tender leaves without hairs and the like, the ants prefer them to the leaves of wild plants. Citrus and cassava are the most popular of domesticated crops to acoushi ants.

Plate 6.12 - Tiny worker ants protecting an egg within the fungus

Plate 6.13 - Preform worker ants

There is only the one species of fungus found in the nests of the acoushi ants in Guyana. The scientific name of this fungus is *Leucocoprinus gongylophora*.

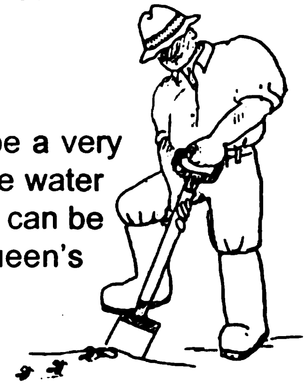
Once established, a nest is difficult to destroy, usually it takes much time and effort to remove a colony. There are control strategies that can be employed however and these are discussed below.

6.3.3 Possible non-chemical control options

These methods represent some of the more effective alternatives to chemical control methods. They and other less well known methods are described below to give farmers and technicians an idea of what control options are available and how best they can be used.

A. Physical control

i. **Digging the nest**: If spotted early, digging out a new nest can be a very good method of eradicating acoushi ants from an area. Where the water table is high, (i.e. when water is found close to the surface), nests can be dug out with comparative ease; follow the tunnels until the queen's chamber is found.



Apart from sometimes being time-consuming, there is the nuisance factor of the attacking ants, trying to defend their nest. It is best to wear stout boots; Wellington boots and thick trousers are best. A good way of keeping the ants down whilst digging is by spraying them with kerosene.

Plate 6.14 - Winged male Acoushi ant, (winged queen looks similar)

The male ants are large, (2" in length) and usually have wings (plate 6.14). The queen is slightly larger, (2.2" in length), and is only winged before and during the bridal flight. Both male and queen are similar in colour to the normal worker ants. The queen will be found in one of the fungus gardens and so each fungus garden discovered should be searched. Once she is found and destroyed, the nest is dead.

ii. **Flooding the nest**: This is best achieved by targeting nests on slopes or at the bottom of slopes. Results are best on clay or firm soils, where the water is retained within the nest. By digging small drains to the main entrance holes, flooding can be achieved. Even partial flooding can cause enough of a nuisance to force the ants to abandon the nest. A bit of digging may have to be done at the nest because it is often higher than its immediate surroundings.

iii **Metal** and **grease bands** around trees: The grease needs to be regularly checked and if necessary, replaced.

When you wipe your hand across a trail or better still use vaseline, the trail scent is removed and the ants become confused. For some time they mill around where the trail scent ends, not knowing what to do. After a while one or two will cross and soon the trail pheromone will be relaid and the trail completed.

iv. **Painting** a broad white band around the base of the tree seems to deter the ants, although for unknown reasons.

v. **Tins** with the bottom cut out are placed around plants. This creates a barrier that the ants cannot climb over.

vi. **Water-filled troughs**, (e.g. car tyres cut in half), placed around small trees or plants keep the ants away from the plant.

vii. In Bolivia, plants with narrow stems like young citrus have been protected from acoushi ants by tying **sheep's wool** around the stem. Ants don't like to cross it and it is almost totally effective.

viii. **Human urine** has a fungicide in it which when poured regularly down a small nest has proved effective.

ix. One farmer is known to have successfully protected his crop from acoushi ants with a strip of **organic debris**, taken from distant ant colonies, placed around the nest attacking his crop. Presumably the ants avoid the smell of ants from other ant colonies.

B. Introducing natural products and botanical pesticides into the nest

The following methods for controlling acoushi ants are taken from experiences in Guyana and from the literature:

i. An often-quoted baiting method is the use of **coconut pulp** - left over after the milk has been squeezed out. This pulp is left to ferment for a few days and then placed near one of the main trails to the nest. The pulp is taken into the nest by the ants, where its presence leads to the nest becoming inactive. Some people place the pulp near the nest without fermentation.

ii. **Mammey** (*Mammea americana*) - the big seeds of this popular fruit can be dried and ground, giving a powder which is effective in killing acoushi ants. The ants have been observed carrying the seed powder into the nest but the effect of this on the nest was not observed. What seemed to work best was when the material was sprinkled around the trail and beyond, (remembering not to touch it with your hands). It can also be poured down the nest holes. This coats and kills the ants coming up through the powder. It would be worthwhile incorporating mammey seed powder into a bait. The possible carrying agent could be "congote" or cassava dust (the material left in the sifter after the cassava flour has been sifted through).

iii. The **Jack bean** (*Canavalia ensiformis*), although untried in Guyana, is supposed to be very promising. In one study in Honduras, the Jack bean was used as a biological control for the acoushi ants. Five to 15kg of leaves were placed nightly on top of and around mounds covering an area of 25 to 100m^2 for three consecutive nights. All the leaves had disappeared by the following morning, the ants apparently preferring them to the plants surrounding the colony. After a single 3-night treatment, nests were usually deactivated for periods ranging from 4 months to 5 years. It is thought that Jack bean leaves may have a chemical which is toxic to the fungus in the nest.

iv. **Research in Brazil has discovered that sesame (*Sesamum indicum*) gives protection against a particular species of acoushi ants, (*Atta sexdens*). Ants take the sesame leaves into the nest, where it supposedly kills the fungus within.**

v. In Region 1, a plant locally known as **Warakabba** (*Renealpina orinocensis*), cousin of the Inkberry bush, is said to control acoushi ant nests. This plant has long bundles of berries, which lie, on the ground. These berries are pounded with some water and the pulp is pushed into the acoushi ant nest.

There are other insecticidal plants found in Guyana that may well have an effect on acoushi ants. See Chapter 5 for more information on these plants. If you decide to try them, make sure to keep records so that others can learn from your experiences.

Attention: Since so little is known about botanical insecticides, they must be treated with as much caution as chemical insecticides.

As well as taking the leaves back to the fungus garden, the ants drink the sap produced at the cut edges of the leaves. They will also drink water and various vegetable oils. They do this for themselves but also it seems that this water is important to the fungus.

C. Alternative botanical control methods

Plants can be used on acoushi ants in ways other than as a direct substitute for synthetic insecticides. A few ideas are presented below.

i. **Kunaparu, Aruarani** (*Euphorbia catinifolia*) - this is a small tree, repellent to the acoushi ants, which if planted in a field of cassava, keeps them away. The tree produces a white, acidic substance which may play a part in warding off the ants. The substance can also give you blisters, so be careful.

ii. **Sorrel** (*Hibiscus sabdariffa*) - in contrast to Kunaparu, this plant is very attractive to acoushi ants, (more so than cassava). When planted in or around a field, the ants will largely ignore the cassava and will cut the sorrel bush. This sort of practice is usually referred to as a scarificial. Sorrel can survive after losing many leaves. Remember, sorrel does normally loses all its leaves once a year, so when it happens, its not just a bad acoushi day.

iii. **Pigeon pea** (*Cajanus cajan*) - this plant acts as a 'trap crop' when grown in large quantities within the crop. This plant has good resprouting abilities, and the flowers of pigeon pea are very, very attractive to the ants.

iv. **Stinging nettle** (*Laportea aestuans*) - when acoushi ants are put on nettle leaves, they curl up and die. This property can be utilised for your benefit.

D. Biological control

There are a few methods of biological control, which have been observed or discussed. Two such methods are discussed below:

i. **Move and encourage colonies of biting ant**, Waramuri (*Azteca* sp.), to take up residence in areas being defoliated by acoushi ants. These ants are very aggressive and will keep the acoushi ants away. Unfortunately they may also keep you away and make your life difficult when harvesting a crop like coffee. These ants could be applied as a useful tool but more research is required.

ii. The placement of bits of **dead animals** down the ant holes. Use of crab, frog and anteater parts is most commonly mentioned in Guyana. This is not entirely biologically correct and its effectiveness is questionable.

ANT FACT

Acoushi ants are attacked by phorid flies which lay eggs into the ants. The fly larvae develop inside and kill the ant.

6.3.4 Chemical control strategies and considerations

A. Baiting

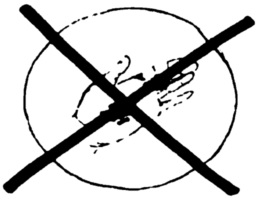
Primarily a bait consists of an **insecticide** and a **carrying agent**. The carrying agent is a vegetable substance, (e.g. soya, dried citrus pulp, cassava, wheat, etc.), which attracts ants to the bait and then induces them to carry it into the nest. Other agents, such as vegetable oils, can also be added to improve the mixture's effectiveness. The bait is usually made into small pellets, easy for the ants to pick up and carry into the nest. In Guyana, baiting is the most commonly recommended and used control method. The ants take the bait into the nest, where it is incorporated into the fungus garden. Ideally the insecticide in the bait is a slow-acting stomach poison which acts at a speed which allows most of the ants, including the queen, to eat the insecticide-laced fungus, before it starts to kill.

Presently there are four types of baits available in Guyana; the local NARI-made, "**Atta**" bait that consists of pale, brown pellets contained in a 200g clear plastic packet. The insecticidal ingredient is Fipronil and the carrying matrix is a mixture of wheat middling and wheat flour. Another bait is from Brazil and is called **Attamex** or **Mirex**. The pellets are browny black and are contained in a clear or white 500g packet. The insecticide in this bait is Mirex and the carrying agent is citrus pulp. The other two baits are relatively new on the market; they are **Fiprokil** and **Logic**. Fiprokil comes in a 100g clear plastic packet and uses the insecticide Fipronil. It has citrus pulp as the carrying agent. Logic is a bait based on an insect growth regulator and comes in the form of pale brown pellets. Insect growth regulators disrupt the normal development of insects, usually resulting in death.

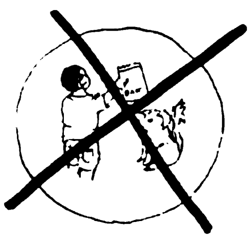
Farmers acknowledge the Attamex, (Mirex) bait as more effective than Atta, though more expensive and more difficult to obtain. Atta does work well but it does not attract ants as strongly as Mirex and has to be placed and handled with more care. **The four baits should not be treated in the same way when using them, each having its individual requirements of application and care**. For example, whereas Attamex can be held by hand and still be effective, the Atta bait cannot. It has to be placed with care if the ants are to take the bait into the nest.

The instructions for using Atta are as follows:

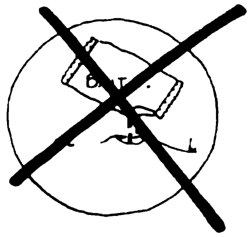
*** Never let the bait get wet**



*** Never touch the bait by hand**



*** Never let the bait near children or animals.**



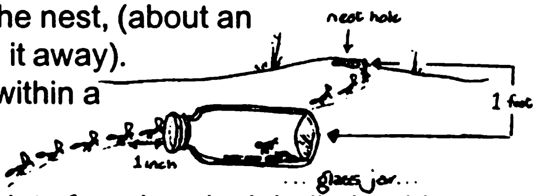
*** Never pour the bait down the nest hole**

While Atta is not a particularly dangerous chemical, as a standard practice, all agricultural chemicals should be kept away from children and animals.

Once workers are following a trail to a worksite, they will not deviate from the trail and so often pass many suitable host plants on their way.

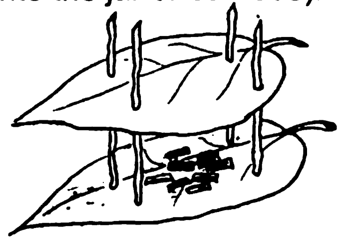
Other considerations for the use of Atta:

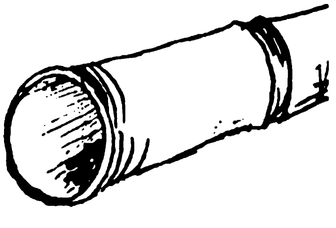
i. The bait should be placed just off the main trails of the nest, (about an inch off), and not on the trail, (as the ants may clean it away). For the same reason the bait should not be placed within a foot of a nest entrance.



ii. Bait which is 6 months past its production date (that date found on the label) should not be used, or bought. The bait is most effective in the first 3 months.

iii. To keep the bait dry, it is necessary to cover it from below as well as from above; this keeps it away from the moisture in the soil. Broad leaves could serve this function, although a jar or hollow bamboo would be preferable, (**Note**: Make sure water doesn't run into the jar or bamboo).





iv. For a large trail, a quarter of the packet should be used. A very large nest may well need 2 packets to eradicate it. Nests are most vulnerable to the use of baits when less than one year old, thus a regular, annual baiting exercise is advised.

v. Avoid excessive handling because the granules will break down to powder, which is not picked up by the ants.

vi. Store the bait in a dry place.

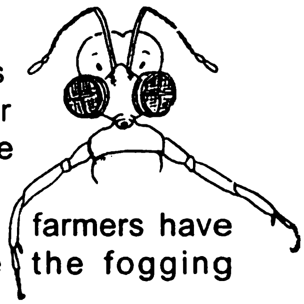
vii. When the ants are engaged in nest cleaning exercises (i.e. when they are observed carrying sand, small stones and other material out of the nest), bait should not be applied.

All these considerations should also be heeded when using the Brazilian Attamex bait, and to some extent, the other baits mentioned - it will make them more effective.

ANT FACT

Scout ants encourage nestmates to areas of new foraging by laying trail pheromones to follow. Pheromones are scents or perfumes made by animals. Worker ants deposit "nest exit pheromones" at all the nest holes. These pheromones last 24hrs and orient workers to the openings, improving the rate of trail-laying, leaf-cutting and retrieval.

B. Fogging of nests with a swingfog machine



This is a very effective but labour intensive method. The fog machine drives an insecticidal fog into the nest, through one of the main holes, after all other exit/entrance holes have been blocked up. An area once fogged remains free of acoushi ants for a very long time. Since a swing fog machine is very expensive, a fogging program is best organised on a community level. Some farmers have used mistblowers as a cheaper alternative to swingfog machines. To facilitate the fogging exercise the following guidelines should be observed:

i. it is very important to clear the bush away from the nest and also to make sure that access to the nest is clear. Without an area fully cleared of underbush, saplings and old wood, it is very difficult during the actual fogging to locate and satisfactorily plug up holes. If leaks exist, the insecticidal fog escapes and the nest will remain active.

ii. It is important that there be an array of tools available during fogging, (i.e. cutlass, spades, forks etc).

iii. Care must be taken when planning not to underestimate the time a fogging exercise requires. In addition to the fogging itself, the nests first have to be found, the bush cleared and the machine filled with fuel and fogging mixture. Nests within a 200 metre range of cultivated land should be destroyed, to ensure full protection of the crops.

iv. For extended fogging exercises, it is important to take all relevant manuals and tools for the fogger and to have somebody trained in basic maintenance.

v. As it is an insecticidal treatment, all those not directly involved with the exercise should avoid the nest area during fogging. Those conducting the fogging should follow all relevant safety advice, which, at the very least, should be the covering of the nose and mouth.

C. Pouring/dusting insecticides and other materials down nest holes

This method of control is by its nature quite inefficient although it works particularly when the nests are newly established. Soil type is an important factor in determining the effectiveness of the method. Clay soils are better at retaining the insecticide in the tunnels and chambers of the nest unlike sandy soils, where much of the insecticide soaks out and away from the nest area. Whatever the soil type, it is difficult for the insecticide to reach all parts of the nest and often the queen is missed. Usually, this type of application of the insecticide only keeps the nest quiet for a month or two, then activities are resumed. This method is only recommended on new, small nests. Very new nests are made conspicuous by numerous pellets of excavated soil deposited around the large (12mm-diameter) entrance.

Gasoline has been poured down nests and lit, giving good results, though this is limited in the same way as explained above. This method also has its obvious dangers. Carbide pellets placed down the holes are said to work very well. Once the pellets have had time to dissolve, a match is lit and the gas produced by the pellet explodes. This method is also dangerous.

The optimum time to apply any chemical practices is before the queen's bridal flight. After the bridal flights there are many more nests to deal with. The bridal flights of the most common types of acoushi ants in Guyana, occur a few weeks after the start of the main May/June rains.

ANT FACT

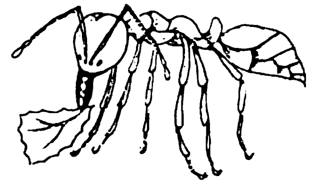
After the bridal flight, when the queen has been fertilised by one of the attendant males, the queen finds a site to make a new nest. Nest excavation begins immediately on arrival. Within the forest, new queens show a preference for starting nests in clear areas caused by tree falls.

6.3.5 **Conclusion**

In dealing with the acoushi ant there are many control methods to choose from. Some are very effective at destroying a nest, while others are not so effective. Where chemical control methods are not possible, a combination of the other methods may work just as well. Dig up the small nests, flood those on slopes and plant sorrel or kunaparu in your crop. Selected trees around the house could also be protected by such methods as banding, greasing or by placing a tin around the tree base. If swing fogging is not possible or baits not available to buy, there are still other ways of keeping the acoushi ant under control. Some of the methods above may well work for you or they may not. Remember to record and communicate to others your experiences. You may find or already have other effective methods. These and the results from your experiences of applying the methods described above are all very useful information. Make sure you tell as many people as possible, even if it sounds stupid.

6.3.6 **Fact sheet**

ACOUSHI/LEAF-CUTTING ANT CONTROL



Biology:

- These insects have a complicated, social structure that makes control actions difficult. They live underground, carefully selecting their food and quickly rejecting anything they find suspicious.
- Only the queen ant can lay eggs and so when she is killed, the rest of the nest follows. She is large, (2-2.5"), brown and sometimes, just before her bridal flight, winged.
- These insects use the leaves they cut, to grow fungus gardens within the nests. The ants then feed on the fungus.

ANT FACT

One species of Acoushi ant, *Atta sexdens*, is identified by a strong citrus smell that occurs when you crush its head!

Control practices:

- Baiting is the most popular method in Guyana. The four available baits at the moment are:

  "Atta" (NARI, local bait)
  "Attamex/Mirex", (dark bait from Brazil)
  "Fiprokil"
  "Logic"

Baits work by mixing a slow-acting insecticide with an attractant that encourages the ants to pick up the mixture and take it into the nest. By the time the insecticide starts killing, most of the ants have eaten some.

- The most effective, large-scale method of control is the use of **swingfog machines**. The one drawback is its expense. The machine works by forcing a oil/insecticide fog through all the tunnels and chambers of the nest. This kills everything. All the exit holes must be plugged to prevent any of the fog escaping. This exercise is greatly helped by clearing the top of the nest before fogging.

- There are many good **botanical** and **physical** methods that also can be applied:
  - flooding the nest;
  - dig the nest to find the queen, (spray kerosene to stop the ants from biting);
  - wrap **sheep's wool** around the stems of young saplings;
  - use **coconut pulp** or **mammey seed** powder as the insecticides for a homemade bait;
  - the berries of the **Warakabba** bush, (cousin of the **Inkberry bush**) pulped with water and pushed down the nest;
  - leaves of the **Jack bean/Cutlass bean** have a chemical which kills the fungus in the nest. Ants will carry the leaves into the nest;
  - **Kunapuru** planted in a field will repel the ants from the field;
  - **Sorrel** and **pigeon pea**, planted within a crop, can be stripped by the acoushi ants but will resprout and continue to divert the attention of the ants away from the crop.

6.4 Diamondback moth in cabbage - field sanitation and careful insecticide management

CASE #4 - "Windows in cabbage leaves"

6.4.1 Introduction

The Diamondback moth, *Plutella xylostella* (L.), caterpillar has become one of the greatest concerns for cabbage growers in Guyana. Many Diamondback moth (DBM) infestations are difficult to eradicate because they have become resistant to most kinds of insecticides that have been used to control insects on cabbage. Under natural circumstances the numbers of DBM caterpillars per plant are kept low due to the presence of beneficial parasite and predator insects, which utilize (and therefore kill) DBM caterpillars as hosts or food. Unfortunately these parasites and predators are highly susceptible to insecticides whereas the DBM is not, resulting in the rapid build up of DBM numbers per plant and increased damage when certain insecticides are used. Currently the best chemical approach to managing the DBM is to minimize destruction of the beneficial insects by using insecticides that are effective on DBM larvae but which don't harm beneficials. At this time the best insecticides for this purpose are those based on *Bacillus thuringiensis* (*Bt*), such as Dipel 2X, Xentari, and MVP. Other insecticides that might be available, such as the Insect Growth Regulators (IGRs) and neem preparations, may have varying effects on parasites and predators. This should be determined early on in the use.

Understanding the life cycle of DBM, the way the insecticides work, and the growth of the cabbage plant are important when making informed decisions on how to spray for Diamondback moth.

Plate 6.15 - Diamondback moth caterpillar

Plate 6.16 - Diamondback moth adult

6.4.2 Biology of the Diamondback moth

The DBM caterpillar feeds only on cabbage and related plants, (i.e. the crucifer family). It is yellowish/green to green and about 1/2" in length when full grown (plate 6.15). The caterpillar is the immature, or larval, stage of a small (about 1/2" long) moth coloured in various shades of brown (plate 6.16). The DBM gets its name from the diamond-like pattern on the back of the male moth when the wings are folded over the back. This diamond pattern is less obvious on the female. As with most moths, the DBM is active mostly at dusk and at night, mating and laying eggs. However, it can be seen to be active during the day, flying about cabbage plants and taking nectar at flowers. The female lays her eggs singly or in small clumps of several eggs on the underside of leaves. Many eggs can also be laid in the bud area of the cabbage plant. Just after egg hatch, the first stage caterpillar bores into the leaf and feeds inside, protected within the leaf, creating a small leaf mine. A leaf mine will show up as a small white trail about 3-5mm in length on the upper leaf surface. The next three larval stages feed on the outside of the leaf. The larvae generally feed from the bottom of leaves, eating through to the upper epidermis, leaving a clear "window pane" over the hole in the leaf (plate 6.17). The "window pane" will often flake out later on, leaving a hole in the leaf. The caterpillar also feeds within the bud or under the cap leaves of the cabbage head where it remains well protected against insecticides and its parasites and predators. There is some evidence that the larvae take avoidance action when insecticide deposits are on the leaf; they move into the bud of younger plants and under the cap leaves of older plants. When the fourth stage larva is mature it spins a delicate, very open cocoon of silk around itself attached to the leaf, (plate 6.18). The larva then changes to the resting stage, or pupa, in the cocoon. The adult, or moth, emerges from the cocoon in about 3-4 days in the tropics. The complete life cycle, egg to adult, takes about 14-15 days in the tropics.

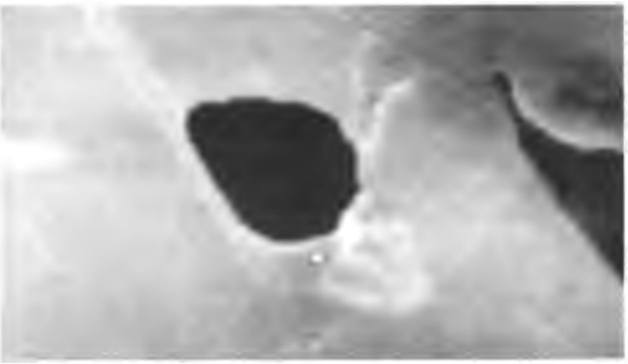


Plate 6.17 - Diamondback moth damage

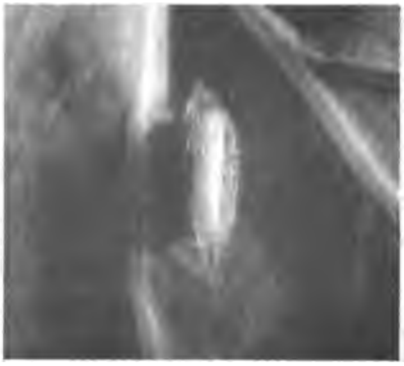


Plate 6.18 - Diamondback moth cocoon

6.4.3 **Management guidelines**

For successful management of the pest it is of utmost importance to suppress the DBM population early in the crop, and crucially to keep transplants clean for planting. If transplants are infested, they should be treated before setting as previously described. It is suggested that when the infestation level is low, insecticides be minimized or not used until the cupping stage or early heading, to preserve any parasites or predators present. The foliage that is present up until the cupping stage is not that which will be present on the final cabbage at the market.

A. Sanitation

Sanitation is a key factor in the management of DBM. This involves destruction of crop remains at least three (preferably four) weeks before planting seed beds or transplanting to prevent a mass migration of moths from crop residues into new plantings. If there are neighboring cabbage growers, some coordination among the growers of activities involving cabbage production would be wise.

B. Clean planting material and management of seed beds

Planting a field out with transplants, free of DBM, is probably the most important thing a grower can do. Starting with DBM-free plants will provide the greatest returns for a farmer. If possible, grow transplants well away from field production areas to minimize possibility of infestation. Several types of cloth row-covers can be used to exclude the DBM from seed beds. The use of row covers is practical in seed beds but may not be practical for the field, unless the fields are very small. Weed control is a problem under row covers. They might have to be lifted to pull weeds. Insecticides might be applied before the row cover is replaced to reduce potential of diamondback moth infestation. The row cover may also be designed to allow sprays to penetrate through to the plants.

If seed beds show signs of infestation (any life stages present or suspicious looking damage), it is recommended that they be sprayed about 6 and 3 days before transplanting and the transplants dipped in insecticide just before setting. A *Bacillus thuringiensis* (*Bt*)-based insecticide, such as Xentari, Dipel 2X, or MVP, is recommended since *Bt* would be the least hazardous to workers. However, longer residual insecticides **(DON'T USE PYRETHROIDS)** should be more effective. Neem preparations and IGRs should also be considered for dipping transplants. If available, abamectin, the active ingredient in Agrimec and Vertimec, should also be considered for dipping transplants. Always use a wetting agent; a couple of drops of liquid soap per gallon of spray is better than no wetting agent at all.

C. Field scouting and monitoring

Start scouting right away and keep scouting, twice a week, if possible, but no less than once per week. Mentally divide the field into four quadrants. Walk a zigzag path through the cabbage field, making sure to visit all four quadrants. Examine ten plants along your path within each quadrant. Randomly choose plants; we suggest sampling every third or fourth plant along your path to avoid concentrating in one area. Avoid sampling plants at the very edge of the field. Try not to walk the same path each time to avoid sampling the same area or plants. For each plant sampled, examine the bud (vertical leaves inward) or head and the next four youngest leaves. Early in the crop this will involve examining most, if not all of the plant. Later on just concentrate on the bud and the four youngest leaves and ignore the rest of plant. Look for the presence of larvae and/or pupae and the presence of insect feeding damage. Calculate the percentage of the plants examined that had larvae and/or pupae present and that showed insect damage. Chart results to monitor infestation and damage trends. The changes in infestation and damage levels can help make informed decisions for managing the DBM.

D. Suggested insecticide program

Even without insecticide resistance, the DBM is difficult to control with insecticides because it is only vulnerable to insecticides for 3-5 days of its 14-day life cycle. This is because the eggs, the first larval stage (the leaf mining stage), the pupae, and the adults are either not susceptible or can escape acquiring a killing dose of insecticide. This "kill window" in its life-cycle of 3-5 days is the only time when a caterpillar will eat or come into contact with insecticides. Since a *Bt* insecticide breaks down rapidly on the leaf surface, applications at 7 day intervals means that many caterpillars enter the "kill window" and leave it without eating a killing dose of the *Bt*. Therefore, applications of *Bt* every 3-5 days is often necessary to gain control of a DBM infestation. Shortening the spray interval may not be as important for other insecticides with longer residual periods but as a recommendation, spraying twice a week may be necessary to gain control of a DBM infestation.

Always use a wetting agent when spraying cabbage, a couple of drops of liquid soap per gallon is better than no wetting agent at all.

DO NOT USE ANY PYRETHROIDS OR CARBAMATES

Avoid using insecticides that are harmful to beneficials and aggravate problems due to resistance, such as pyrethroids and carbamates (see Appendix 1). Therefore, *Bt* (Xentari, Dipel 2X, MVP, etc.) should become the primary insecticide for the management of the diamondback moth. It is strongly suggested that when *Bt* is used routinely, *Bta* products (such as Xentari) and *Btk* products (such as Dipel 2X and MVP) should be applied in rotation in order delay the onset of resistance to any one product. There is enough difference between *Bta* and *Btk* to justify this rotation.

If a new planting is obviously heavily infested after the plants recover from transplant shock (about 7-10 days after transplanting), start spraying immediately to gain control of the infestation. The idea is to reduce and then maintain a low level of infestation or damage to the bud and the next four youngest leaves. Scout twice weekly, as previously described, and record on a chart to show infestation trend.

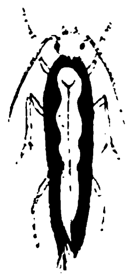
Two insecticide programs for DBM are given as follows:

Program 1: To gain control of a population (i.e. reducing percent infestation level), spray twice per week (3-5 days apart). The first application should be a combination of ***Bt***, such as Xentari, Dipel 2X, or MVP, mixed with **neem** (either preparations of neem from local trees or commercial formulations of neem that might be available). Continue spraying twice per week with *Bt* (alternating between *Bta* and *Btk* if possible) and mix it every other time with either neem, an IGR, or an organophosphate (Appendix 1) [NO PYRETHROIDS]. Use *Bt* at 1/2 lb per acre to minimize cost. If infestation level continues to increase, go to 1 lb per acre.

Program 2: If abamectin (Agrimec or Vertimac) or an equally effective insecticide, is available, use the following program. Apply one application of abamectin right away and then every 14 days. During the alternate weeks when abamectin is not sprayed, apply *Bt* twice, 3-5 days apart (one application of *Bta* and one application of *Btk*). In essence this program is a weekly alternation of abamectin and *Bt*, with the abamectin being applied once during its week and the *Bt* being applied twice (*Bta* and *Btk*) during its week. Additional control could be provided by combining neem, an IGR, or an organophosphate (Appendix 1) [NO PYRETHROIDS] with one of the applications of *Bt*. Staying with a *Bt*/neem program should result in minimum interference with the activity of beneficial insects.

6.4.4 Fact sheet

DIAMONDBACK MOTH CONTROL IN CABBAGE



Diamond back Moth ....

Biology

- The Diamondback moth gets its name from the diamond-like pattern on the back of the male moth. The adult moth is brown while its caterpillars are yellowish/green and about 1/2" in length when fully grown.
- After the eggs have hatched there are four stages of caterpillars. The first stage feeds within the leaf producing a small leaf mine (more like a splotch or short lines, not like leafminer). The next 3 stages feed on the outside of the leaf, producing 'windows' and holes in the leaves.
- The caterpillar avoids insecticides sprayed on the cabbage by feeding within the bud or under the cap leaves of the plant. The first caterpillar stage is found within the leaf and so is not exposed to the insecticide. This behaviour means that during the 14-day life-cycle of the pest, it is only vulnerable to insecticides for 3-5 days. This influences the use of insecticides.
- Diamondback moth feeds only on the plants of the cabbage family, (e.g. Pak choi), including weed species.

Control

The most effective strategies are consistent with IPM practices.

- **Sanitation** - destroy all crop remains at least 3-4 weeks before planting in the seed beds or transplanting to fields. Keep the area free of all weeds.
- **Pest-free planting material** - planting a field out with transplants free from diamondback moth is the most important thing a grower can do. If you receive transplants from somebody else make sure they're pest free. If not dip them in an insecticide just before setting.
- **Seed bed management** - grow transplants well away from field production areas. Use row-covers if possible, making sure that weeds are kept under control.
- **Scouting and monitoring** - scout regularly for diamondback moth in your crop, covering as much of the field as possible. Select a sample number of plants and examine the head and next four youngest leaves for larvae, pupae and feeding damage. Record percent infestation.
- **Natural control** - natural parasites and predators can keep diamondback moth damage to low levels if they are not affected themselves by insecticides.
- **Insecticide use** - DON'T USE ANY PYRETHROID OR CARBAMATE INSECTICIDES. Diamondback moth is very susceptible to developing resistance. *Bacillus thuringiensis* (*Bt*) based insecticides are recommended because of their low impact on beneficial insects. *Bt* insecticides have to be eaten to kill and the beneficial insects, unlike the pests, do not eat sprayed cabbage leaves. Because the caterpillars often feed in hard to reach places, a wetting agent should be mixed with the insecticide. Liquid soap or a little soap powder should help.

One suggested spraying program to gain control of a DBM outbreak:

> Spray twice a week with a *Bt* insecticide, (alternating between *Bta* [Xentari] and *Btk* [Dipel, MVP] if possible) and mix the insecticide every other time with either neem, an insect growth regulator (IGR) insecticide or an organophosphate insecticide, (see Appendix 1)

6.5 Notes on paddy bug, control and potential control measures

CASE #5 - "Ghandi in rice"

6.5.1 **Introduction**

The Paddy bug, *Oebalus poecilus*, is commonly known as the 'Ghandi' and is considered one of the most serious insect pests of rice in all rice-growing areas of Guyana. The reason why it is such a major pest is because of the extensive damage caused by both the newly hatched, growing insects and the adults. Juvenile and adult insects have needle-like piercing and sucking mouthparts. They bore into the young juicy grains and extract the milky material needed to form the grain. If the attack is severe, the grain fails to develop and 'wind rice' is produced. As the rice plant matures, feeding continues on the grains and results in malformation and discolouration of the grain. It has been suggested that the discolouration is caused by fungi that have been carried into the grain by the insects. During the milling process, damaged grains produce at best, blemished or broken grains and at worst grains which are crushed to produce fine chips and bran. Where rice has been parboiled, damaged grains have black spots that reduce the quality of the finished product. The overall effect of this insect is to reduce field yields; to reduce milling yields; to lower the quality of rice produced; and thus to lower the income generated.

6.5.2 **Biology of the Paddy bug**

The adult female lays about 200 cylindrically shaped eggs on various parts of the rice plant, such as the leaf, maturing grain or stalk (Figure 6.8). Newly laid eggs are light green but these soon change to deep red. After about 3-5 days, eggs hatch into young paddy bugs, which are red and black in colour. The young appear similar to the adult, except that their wings are not developed and are smaller in size. As the young outgrows its skin, it sheds the old one several times and at the end of 15-17 days, becomes an adult. Mating takes place and eggs are laid again.

The adult Paddy bug does not live more than a month. Many generations starting from egg, through nymphal stages, to adult are possible annually. In most cases, between 1-2 generations will develop on a rice crop. Remaining generations are completed on the seeds of wild grasses such as Flower grass (*Echinochloa crusgalli*), Bird seed grass (*Echinochloa colonum*) and Bamboo grass (*Hymenachne amplexicaulis*). These grasses provide a breeding ground for this insect and often it is from this reservoir that the attack on the crop is launched. A weed, Red rice, matures earlier than normal rice, and can also serve as hosts for Paddy bugs.

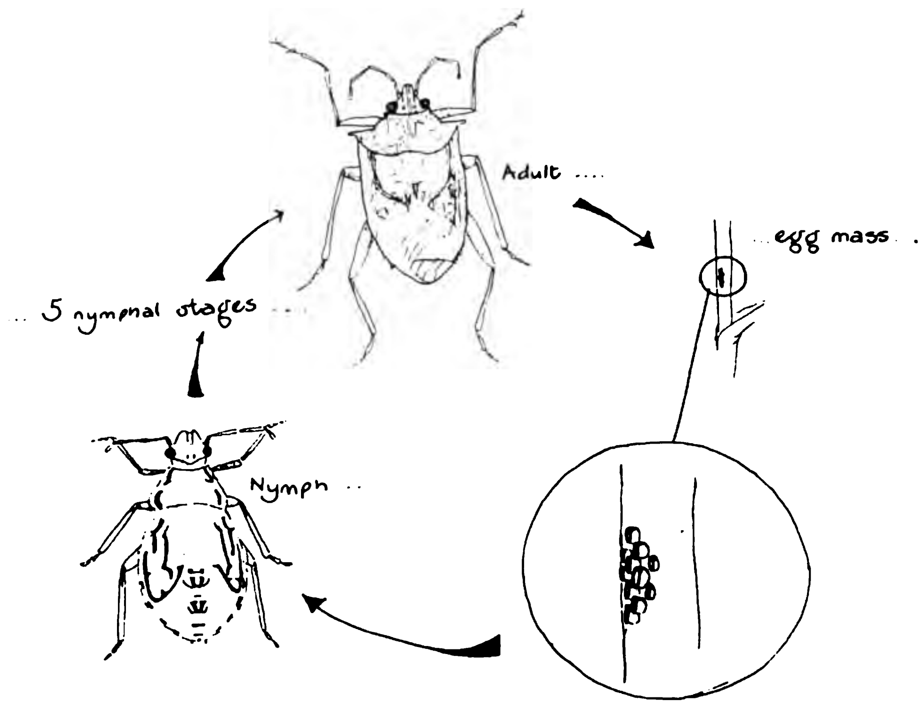


Figure 6.8 The Paddy bug life cycle

6.5.3 **Control measures**

A. Weed Control

Since it is known that Paddy bugs migrate from grass weeds, it is important to control these weeds. A number of strategies can be used to control grass weeds. Hand weeding is well known and is most effective against young weeds that have not had a chance to store up root reserves. Ploughing helps to damage grass weeds as well. Other strategies include burning and the use of weeders. Rotary weeders, for example, can be hand-held and powered by small engines or alternatively can be tractor-driven.

Weeds should generally be controlled as early as possible to minimise their negative impact on yields. In the control of paddy bug, early weed control is especially important. The Paddy bug feeds on the developing seeds of mature weeds, allowing it to grow in numbers. Grass weeds can sometimes be controlled by making sure that clean paddy, free of weed seeds, is planted. Additionally, farm machines and equipment must be cleaned before entering fields.
Weeds can also be controlled by chemicals. Propanil has been used for a long time in the rice industry to control grass weeds. It is most effective when the weeds are young. Other herbicides are also available, (there are over 150 of them available). It is critical that advice be obtained on which herbicide to use. Serious and Saturn have shown promise as pre-emergence herbicides for broad spectrum weed control in rice while Propanil, Tiller and mixtures of Propanil with Grandstand and 2, 4-D and Tiller and 2, 4-D showed acceptable activity as post-emergence control of grass weeds (Guyana Rice Developement Board, 1998). Always follow the instructions on labels. Bear in mind that when properly used, herbicides provide a practical, cost-effective and robust means of weed control. Caution should be taken as they can be toxic to fish and livestock and hazardous to man's health.
Many of the grasses that sustain populations of Paddy bug grow only in dry fields. Flooding of the

fields before sowing can be an effective way of controlling their growth.

B. Block sowing

Sowing paddy seed of the same maturity period in large-acreage blocks can help in several ways in the fight against paddy bug. This practice primarily means that in an area where block sowing is practiced, there is only one window of opportunity for the insect to feed and multiply, (i.e. when the plants have flowered to the time the grain has just reached maturity). In an area with block sowing, there is no extended growing season with plants at various stages of development, This would give the pest an opportunity to move from field to field selecting those where the plants have the most appropriate grains to attack. In other words, synchronous or block planting means that the food resource is only present for a given period and not for an extended period as with asynchronous planting. This is an important cultural control for the Paddy bug.

Another benefit of block sowing is that monitoring of the field can be done quickly. A small sample can be representative of the whole area. Also when an appropriate control action is taken it can be applied efficiently over large areas, using either motorised knapsack sprayers or even aerial spraying of insecticides.

On large rice farms, block sowing is actually practiced and combined with complementary control measures gives satisfactory control over the paddy bug. However, in small farms, this control practice can become difficult because many farmers for various reasons cannot begin the crop at the same time. Where possible, those constraints on starting the crop on time must be weighed carefully by groups of farmers with adjacent plots. Perhaps factors such as the availability of water, machines and equipment, seeds, fertilisers, pesticides, cash, repairs to access dams, etc. can all be controlled so that through better cooperation the blocks can be planted. This will take a tremendous amount of planning by farmers, extension agents and a number of other players.

C. Crop rotation

Some rice farmers have tried planting blackeye peas in rotation with rice. Changing the crop in this way helps in preventing pest build-up. The advantages and disadvantages must be carefully considered before adopting such a rotation. Factors such as degree of risk of crop failure, market conditions, economic returns, etc. will no doubt play an important part in decision-making.

D. Chemical control

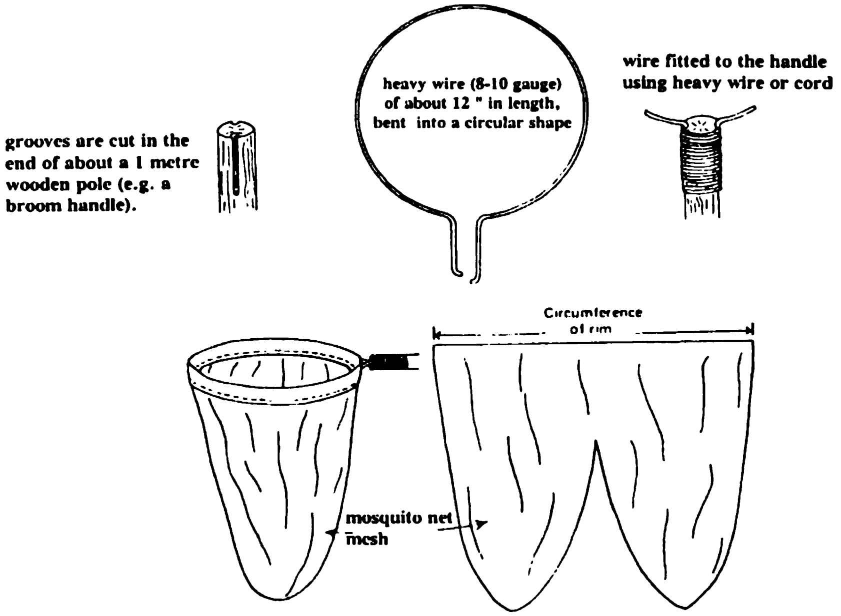
Several factors need to be considered when deciding whether chemical control measures should be used or not. These have been discussed in Chapters 3 and 4. Traditionally, two pesticides have been found to be effective, and have been in use for a long time. These are monocrotophos, a highly toxic material, and sevin. Some very useful guides to paddy bug control are given in rice extension circulars produced by the Guyana Rice Development Board (GRDB).

i. Inspection and sampling

Check fields for paddy bug before 7.00 a.m. or after 5.30 p.m. At other times of the day, they are mostly in hiding or are resting. Absence of the bug on the inspection day does not mean there will be none there tomorrow, so check every third day. You can make an insect net by using an old mosquito net, a wire hoop and a piece of stick. Use the net to sweep over the canopy of the crop while walking the field. Collect bugs from at least 15 well-spaced spots in a 15-acre field. At each spot make 5 sweeps of the net.

A count of 5 or more bugs per set of 5 sweeps is considered a high level of infestation and the field is in immediate danger and would need to be treated without delay. If the number is less than 5 for every 5 sweeps, the population level may be considered low. In this case, you need not spray the field. However, you need to keep monitoring the population regularly. Note that in caged studies, three bugs per panicle have been shown to cause about four percent pecky rice.

How to make an insect net



ii Pesticide use

Monocrotophos is highly dangerous to man and animals. If you cannot follow the precautions on the label, do not use the product. Use carbaryl instead or any pesticide which has been recommended. You can spray using a hand-operated knapsack or a motor blower. Spray only when the conditions are not windy. Also do not spray if there is the threat of rain since rain will wash the insecticide off the plant. It is important to monitor the success of the pesticide by examining the field about 4 days after treatment. Sometimes, it may be necessary to treat again. Remember to calibrate your sprayer and follow the instructions on the label carefully to get the best results.

Paddy bug attack only begins when the plants have started flowering. Try to spray the insects just after the eggs hatch. If you are using monocrotophos you do not have to consider timing of the sprays. If this insecticide is not being used, you need to spray just before 7-8am or just after 5pm so as to catch the insects when they are feeding. In observational plots at Burma the following pesticides have been shown to be effective against Paddy bug: Sumibas (fenitrothion + osbac) 200 ml/acre, Regent 200 SC (fipronil) 100 ml/acre and monocrotophos + Fastac (monocrotophos 60% EC + alphacypermethrin 5% EC) 284 + 40 ml/acre. Additional studies are being carried out to relate efficacy and grade of paddy produced (GRDB, 1998).

6.5.4 **Control strategy developments**

A. Forecasting pest attack

If Paddy bug attack could be forecast, then control measures could be put in place so as to preempt and therefore minimise damage. Unfortunately, successful forecasting is very difficult. To make accurate predictions, elaborate and complex studies, based on the seasonal abundance of the pest, life history and effects of environmental factors, need to be undertaken. Also, most of the experience and information needed for forecasting has only been acquired for temperate systems. Regular monitoring of pest populations by sampling and scouting can give simple measures of what is already there and therefore what to expect. It is important to continue sampling past the application of control measures as this will give you information on how successful your control program is and how possibly it could be modified.

B. Time of Sowing

Generally, early or late crop sowing may avoid the period in which paddy bugs lay eggs. Scientific studies into the means of cultural control, against the paddy bug in rice, have not been done here and until then, recommendations cannot be given. Nevertheless, you may wish to do small trials to find out whether this technique is applicable.

C. Research on integrated control methods

The GRDB is presently investigating a number of aspects of the paddy bug problem. Investigations are directed at: seasonal abundance of pest complexes in rice, estimation of yield losses in terms of quantity and quality, insecticide evaluation, use of disease-causing fungus, and surveillance, monitoring and reporting of pest complex with special reference to this pest.

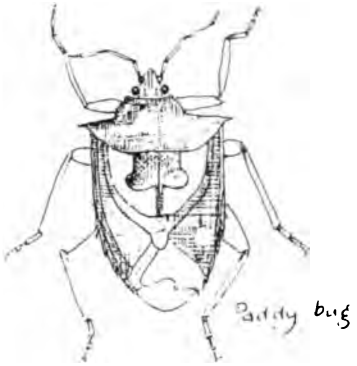
These studies are designed to provide information that will help:

- to determine thresholds so that proper control advice can be given to farmers;

- to promote alternative control methods using less toxic chemicals and bioagents;
- and to give the capability to forewarn against any possible pest build-up.

The thrust of this research is clearly integrated and is focused on a number of different methods.

6.5.5 Fact sheet



CONTROL OF PADDY BUG IN GUYANA

Biology

- The Paddy bug lays eggs on wild grasses such as Flower grass, Bird seed and Bamboo grass and on rice.
- Adults and newly hatched insects damage the grain from the milk stage to hard dough stage in rice.
- Life cycle from egg to adult is about 18 -22 days.
- Many generations are possible over a year.
- Feeding by insects cause reduced field yields, milled yields and the lowering of quality of the finished product.

Control options

What can you do?

- **Do nothing** if infestation levels are low (that is, less than five insects in five sweeps of the net used in scouting).
- **Remove the weeds** on which paddy bug is known to feed and breed on. **Weeding, flooding, use of clean seeds** and the **herbicide** Propanil can help in controlling paddy bug hosts.
- Paddy bug attack is known to be more severe when fields are planted in a staggered (asynchronous) manner. Try to cooperate with growers in adjacent fields to have **block sowing** and **use varieties with the same maturity time.**
- Where possible **rotate planting rice** with black eye peas where this is acceptable.
- At all times **monitor your crop**.
- If infestation level is high, (that is more than five insects in five sweeps of the net), then you can apply **an insecticide** (e.g. monocrotophos). This pesticide is a systemic one and hazardous to use. You must therefore follow the label instructions or those issued by the GRDB carefully.

APPENDIX 1 – SOME COMMONLY USED AGRICULTURAL INSECTICIDES IN GUYANA

Trade Name	Common Name	Chemical Type	Formulation	Hazard Class
Actellic	Pirimiphos-methyl			
Admiral		IGR		
Agree	Bt (Bacteria)	MB		IV
Ambush	Permethrin	PY	EC	III
Applaud	Buprofezin	IGR	WP,D,G,SC	III
Azatin EC	Azadirachtin	BT		IV
Basudin	Diazinon	OP	EC	II
Danitol	Fenpropathrin	PY		
Decis	Deltamethrin	PY	EC	III
Dipel, MVP	Bt (Bacteria)	MB		IV
Dipterex	Trichlorfon	OP	SP	III
Elsan, Cidial	Phenthoate	OP	EC	II
Fastac, Pestac	Alpha cypermethrin	PY	EC,SC	II
Folithion	Fenitrothion	OP	EC	II
Fipronil	Fipronil		B	
Hostathion	Triazophos	OP		
Karate	Lambda cyhalothrin	PY	EC	III
Logic	Fenoxycarb	IGR	B	
Malathion	Malathion	OP	TE,EC	III
Match	Lufenuron	IGR		
Mirex	Mirex	OC	B	
Mocap	Ethoprophos*	OP	G	II
Nuvacron, Azodrin	Monocrotophos	OP	SC	Ib
Padan	Cartap		WP	III
Pegasus	Diafenthiuron			
Sevin	Carbaryl	C	WP	II
Tambo	Curacron & Cypermethrin	OP	EC,WP	II-III
Vydate L	Oxamyl*	C		
Xentari	Bt (Bacteria)	MB		IV

* nematicides also

Key

Formulation

- **WP** - wettable powder
- **EC** - emulsifiable concentrate
- **SC** - water mixable liquid
- **SP** - soluble powder
- **D** - dust
- **B** - baits
- **G** - granule

Hazard Class

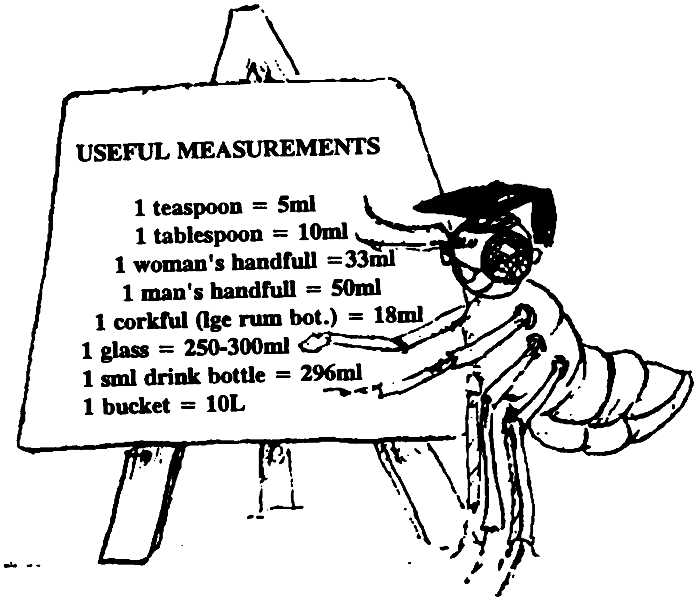
- Ia - Extremely hazardous
- Ib - Highly hazardous
- II - Moderately hazardous
- III - Slightly hazardous
- IV - Unlikely to present hazard in normal use

Chemical Type

- **OP** - organophosphate
- **OC** - organochloride
- **C** - carbamate
- **PY** - pyrethroid
- **IGR**- insect growth regulator
- **MB** - microbial agent
- **BT** - botanical

APPENDIX 2 - CONVERSION TABLE

Unit	A	B	A to B	B to A
Weight	oz	g	x 28.35	x 0.0353
	lb	kg	x 0.454	x 2.205
	ton (long)	kg	x 1016	x 0.000984
	ton (short)	ton (long)	x 0.893	x 1.12
Surface Area	in^2	cm^2	x 6.45	x 0.155
	ft^2	m^2	x 0.093	x 10.764
	yd^2	acres	x 0.000207	x 4840
	acres	hectares	x 0.405	x 2.471
Length	in	cm	x 2.54	x 0.394
	ft	m	x 0.305	x 3.281
	yd	m	x 0.914	x 1.094
	rod	ft	x 12	x 0.0833
	mile	km	x 1.609	x 0.621
Quantities/Area	lb/acre	kg/ha	x 1.12	x 0.894
	gal (Imp.)/acre	L/ha	x 11.23	x 0.089
	gal (USA)/acre	L/ha	x 9.346	x 0.107
	oz/acre	g/ha	x 70.05	x 0.0143
	oz/acre	kg/ha	x 0.07	x 14.27
Volume	fl. oz (Imp.)	ml	x 28.35	x 0.0352
	fl. oz (USA)	ml	x 29.6	x 0.0338
	gal (Imp.)	gal (USA)	x 1.20	x 0.833
	gal (Imp.)	L	x 4.55	x 0.22
	gal (USA)	L	x 3.785	x 0.264



USEFUL MEASUREMENTS

1 teaspoon = 5ml
1 tablespoon = 10ml
1 woman's handfull =33ml
1 man's handfull = 50ml
1 corkful (lge rum bot.) = 18ml
1 glass = 250-300ml
1 sml drink bottle = 296ml
1 bucket = 10L

UNITS, ABBREVIATIONS AND SYMBOLS

oz - ounce	cm - centimetre	ha – hectare
G - gram	m - metre	gal (Imp.) – Imperial gallon
lb - pound	yd - yard	gal (USA) – US gallon
kg - kilogram	ft - foot	fl. oz – fluid ounce
in - inch	km - kilometre	ml - millilitre
ha - hectare	L - litre	

APPENDIX 3 – SOME ORGANISATIONS TO CONSULT ON IPM IN GUYANA

RESOURCE AREA INSTITUTE	Crop protection advice	Pest Identification	General crop information	Botanical information	Training	Soil Analysis	Library facilities	Accessibilty to facilities, resources & personnel	Other services, facilities or information available
NARI, (National Agricultural Research Institute)	***	***	***	*	**	***	***	***	IPM orientated; insect collection; pesticide registration; neem research
Ext. Services, MoA	***	**	***	*	***	*	**	***	farmers' main link with MoA
Plant Quarantine, MoA	**	**	*	*	*			**	import/export certification; pesticide regulation
Herbarium, UG				***			*	*	large plant collection
Biodiversity Centre, UG				***			**	*	international links; plant information
Agriculture Dept., UG	*	*	**	*	***		*	**	structured courses
IICA	*		**	*	**		**	*	animal & plant health projects; international links
CARDI	**	**	**	*	**	*	*	**	Caribbean links; research organisation
Forestry Commission				**	**		*	**	knowledge of useful forest species
Guyana School of Agriculture	*	*	*	*	***	*	**	**	structured courses; short-term courses
GUYSUCO	*	*	**		*	***	*	**	IPM experience in sugar
GMC, (Guyana Marketing Corporation)	*	*	**		*			**	Information on crop damage related to marketing
Caribbean Chemical, Amazon Chemicals, Ainlim	***	***	**		*	*		***	Commercial agrochemical companies
GRDB	*	*	**		*	*	*	***	Rice

Note: *** - strong emphasis ** - moderate emphasis * - fair emphasis blank - no significant emphasis

APPENDIX 4 – LOCAL PLANTS WITH POSSIBLE CROP PROTECTION USES

Agya-pani, Red-head plant, Silkweed (*Asclepias curassavica*)

General: This is a weed of pastures and waste ground. It has a number of medicinal uses including a cure for ringworm, sores, rashes and dermatitis.

Insecticidal properties: Its leaf extract in alcohol and ether has shown attractancy to the male and female adults of certain fruit fly species, (ie. *Dacus* sp. and *Bactrocera* sp.), which means it could be used against the carambola fruit fly (*Bactrocera carambolae*).

Additional information: - Extracts have proved toxic to rabbits and rats.

Barka tree, Surinam cherry (*Eugenia uniflora*)

There are 50-75 *Eugenia* species found in Guyana. The powder from the flower, bud and/or cloves of some *Eugenia* species has demonstrated useful properties.

Bat seed, Karoro (*Andira inermis*)

General: It is found in the forests of Guyana. A tea made from the bark is used for deworming and cleaning the system. The inner bark is scraped and used as an antidote for snake bites.

Insecticidal properties: Twigs have been used to make nests for "setting hens" since the scent is thought to discourage mites and fleas.

Additional notes: - the fruit is thought to be poisonous.
- the seed is burnt in homes to get rid of bat infestations.

Berry leaf flower (*Phyllanthus acuminatus*)

This is a perennial shrub found in Guyana. Dried powder of its root was reported to be insecticidal against melonworm and the diamondback moth. **Konali** or **Surinam bitters**, (*P. amurus*) is included in the 20 plus *Phyllanthus* species found in Guyana.

Bitter cassava (*Manihot esculenta*)

Unconfirmed work has found that the juice extracted from the root is toxic to insects. This same juice does have nematicidal properties.

Bitter gumma, Black calalu (*Solanum americanum*)

This is a common weed found in cultivated land and disturbed land. It is used medicinally to purify blood and it causes diarrhoea to expel worms. Its whole plant and fruit extracts in water show insecticidal and antifeedant activities. It must be noted however that this species is described as a potential human health hazard. There are 75-100 *Solanum* species found in Guyana, including **Bura bura, Bulbuli** and others. The literature shows many of the *Solanum* family to be insecticidal.

Boyari (*Aristolochia daemoninoxia*)

General: This woody climber is found high in the trees of the forests of Guyana. It has many medicinal uses including as an oral contraceptive for women.

Insecticidal properties: Many *Aristolochia* species have useful activities against a large number of insect pests. Poison hog meat (*A. grandiflolia*) is a plant found in the mountain bush of Jamaica and extracts from this have shown insecticidal activity against the cabbage worm.

Bur-Marigold, Spanish-Needle (*Bidens alba, B. cynapiifolia*)

General: This is a common weed along roads and waste places. It is used medicinally against diabetes and baby thrush.

Insecticidal properties: Bidens pilosa, which is also found in Guyana, has proven insecticidal and antifeedant properties against bug (hemipterous) pests. The other *Bidens* species may also show useful properties.

Bush rope, Devil doer (*Strychnos* spp.)

Extracts from the plants of the *Strychnos* genus have many uses, including as a mammalian poison, a fish poison, and an aphrodisiac. The insecticidal properties of these plants have not been established. One reference, on the insecticidal activity against termites, was found for a *Strychnos* sp.

Carrion-crow bush, Wild senna (*Cassia alata*)

General: This is a short-lived shrub found commonly in Guyana. It has numerous medicinal properties and is used against biliousness, hypertension, constipation, griping, pneumonia, colds, ringworm and various skin diseases.

Insecticidal properties: Bark and leaf extracts were found to be toxic to common black and red ants. *Cassia fistula*, (Indian laburnum), also found in Guyana, has been used against the pulse beetle, termites and various bugs. It is also used to protect grain and beans against storage pests.

Additional notes: - there are over 50 different *Cassia* species and the closely related *Senna* species in Guyana. How many of these have insecticidal properties?

Cashew, Merche (*Anacardium occidentale*)

General: This gnarled tree is found throughout Guyana. The Rupununi is an area of concentration for this tree. A tea made from the bark is used against diarrhoea and mouth ulcers.

Insecticidal properties: Extracts from all parts of the tree show insecticidal and repellent properties against termites and the white coffee borer. Oil from the seeds showed toxicity to the red cotton bug and the cotton armyworm.

Chinaberry bush (*Melia azedarach*)

This tree originates from Asia. It has been long recognised that few insects feed on the tree. Water extracts of the leaves have shown repellency and toxicity to various insect species.

Crabs-eyes, Lickrish, Wild liquorice (*Abrus precatorius*)

General: This is a slender, woody twiner found alongside roads and paths and found growing up fences. It has a number of medicinal uses including treatment for bellyache, thrush, colds, ulcers and certain eye problems.

Insecticidal properties: In previous work a preparation of the fruit was used to kill feeding grasshoppers. The fruit was crushed and soaked overnight in water. The mixture was then filtered and a small amount of soap powder added. The mixture was then ready to spray.

Eucalyptus, Red river gum (*Eucalyptus camaldulensis*)

This is a cultivated tree in Guyana; its distribution is not that well known. Extracts of *Eucalyptus* spp. have repellency properties but are best known for their growth disruption activities on insect.

Garlic (*Allium sativum*)

Although this plant is not grown here, the bulbs are available. In field and laboratory tests extracts have been shown to be effective against insects, nematodes, ticks, fungi and bacteria.

The oil extract from the cloves is the most effective form for use against insects. Instructions are given below for one use of garlic in a field spray preparation:

- 85g of chopped garlic are added to 50ml of mineral oil and left to stand for 24hrs. Afterwards 450ml of water, with a half handful of soap, is mixed into the oil. The mixture must be shaken well to form the emulsion and then filtered through a fine cloth. For application one part of the emulsion should be added to 19 parts of water. This is mixed and then sprayed, preferably early in the morning. Depending on your pest needs you may have to change the dilution factor of the emulsion before spraying.

Goat Weed (*Ageratum conyzoides*)

This is an introduced species into Guyana. It is a small shrub with tubular flowers, white or violet in colour. It does not have any particular soil requirements but does prefer moist and sunny conditions. It has shown useful insecticidal, growth disrupting and repellency properties against a number of insects. Planting this plant will protect neighboring plants from attack. Plant material can be worked into the soil as another means of protection. Powder from dried plant material and various extracts have been used against a number of insects - field and storage pests. This plant is grown in combination with legumes as a successful soil improvement regime under orchard crops such as coffee. Goat weed is a nematicide and can also keep down weeds.

Hibiscus (*Hibiscus rosa-sinensis*)

This ornamental bush is very common in Guyana. Aqueous extracts of the flower are toxic to the rice weevil. 10ml of the extract was added to 100g of rice to give good protection.

Hikuri bianda (*Simaba cedron*)

This is a small tree with a characteristically unbranched trunk found in wooded areas. Water from the boiling of the bark and seeds is used as an antidote for snake bites and mild fevers. A powder is made from the dried leaves and used for the treatment of mange in dogs and the control of mites and ticks.

A relative of this tree, *S. multiflora* shows insect growth disruption activities.

Lion bush (*Leonotis nepetifolia*)

This is a common weed found in fields, roadsides and waste places. It has a number of medicinal uses. The dry powder of the leaf and seeds of this plant are reported as having toxicity against the bean leaf beetle, melonworm and the cotton bug.

Madar-flower, Waraio-balli (*Calotropis gigantea*)

General: This plant is commonly found in East Indian yards as it is used in Hindu functions. It is also found in open disturbed areas. Medicinally the milky sap is applied externally to treat burns, bruises, cuts and sores. A tea can be drunk for heavy chest colds and heart conditions.

Insecticidal properties: Water, alcohol, petroleum or kerosene extracts of all parts of the plant have shown insecticidal and antifeedant properties against the rice weevil and various caterpillars. Water extracts of the leaf have been sprayed on watermelon and vegetable crops to prevent locusts from feeding. Various extracts have been used effectively against aphids, stem borers and leaf beetles.

Never-done, Old Maid, Periwinkle (*Catharanthus roseus*)

General: This plant has spread around the world as a popular ornamental herb. Medicinally, extracts from the plant are taken orally to control hypertension, diabetes and "dropsy".

Insecticidal properties: Root and leaf extracts in water show insecticidal, antifeedant and growth disrupting properties when used against various caterpillars. The same aqueous extracts were shown to kill the yellow stem borer of rice and bug pests found on cotton.

Pomegranate, Anar (*Punica granatum*)

This large fruit is found in the markets of Guyana when in season. Medicinally the bark is boiled and the water taken for instant relief of diarrhoea. Its dried leaf powder has shown toxicity to the diamondback moth.

Sandbox (*Hura crepitans*)

This tree is recognised by its characteristic fat trunk. It is found in open forest. The juice or aqueous extract from the branch of this tree is toxic to a species of caterpillar.

Stachytarpheta mutabilis

This Guyanese plant is a close relative of the **Burr vine** (*S. cayennensis*) and **Blue vine** (*S. jamaicensis*), which are also found here. *S. mutabilis* is a shrub, common in rough pastures. The leaf extract contains a compound that shows antifeedant properties to locusts and armyworms.

Surinam poison, Kunali (*Tephrosia sinapou*)

This is a shrub often found in waste places. The stem and leaves are used as a fish poison. The crushed leaves are also used on sores to bring relief or used to wash hair to remove lice. Its root extracts in water, alcohol and petroleum ether were reported to show insecticidal and antifeedant activities to the winter moth.

Tamarind, Imli (*Tamarindus indica*)

This is a common tree in Guyana, the fruit of which is used to make a fruit drink and a sweet. It has medicinal uses. It has been recorded that this tree was planted and it managed to control a red locust outbreak. Perhaps the tree is planted around the crop and acts as a barrier/trap crop?

Toyeau (*Justica pectoralis*) & St John's bush (*J. secunda*)

The leaf powder of another *Justica* species found in Guyana, *J. betonica*, is used to protect stored grains.

Yellow Oleander (*Thevetia peruviana*)

This is an ornamental shrub that can be found in the yards of Guyana. Its leaf and fruit extracts and oil were found to be toxic to aphids, pulse beetles and various storage pests. Repellency and growth disrupting qualities have also been reported. Toxicity of *Thevetia* species to humans is well documented. Care should be taken with this plant.

Plants which belong to the same genus as insecticidal plants. Possible insecticidal properties have yet to be established in these plants.

Baby semitoo, Mis mis (*Passiflora foetida*), Bell apple, Semitoo (*P. laurifolia*)
Bastard Crabwood, Buck-vomit (*Guarea guidonia, G. pubescens* [Kufi-balli])
Blue flea bane, inflammation bush (*Vernonia cinerea*)
Cockshun, Dorok waropimpla (*Smilax schomburgkiana*)
Daisy, Creeping Daisy (*Wedelia trilobata*)
Deer calalu (*Phytolacca rivinoides*)
Jamoon (*Syzygium cumini*)
Pain killer, Yaw weed (*Morinda citrifolia*)
Teasam (*Lippia alba*), Fineleaf thyme, (*Lippia micromera*)
White cedar, Warakuri (*Tabebeuia insignis* var. *monophylla*)
Woman-piaba (*Hyptis pectinata*)

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