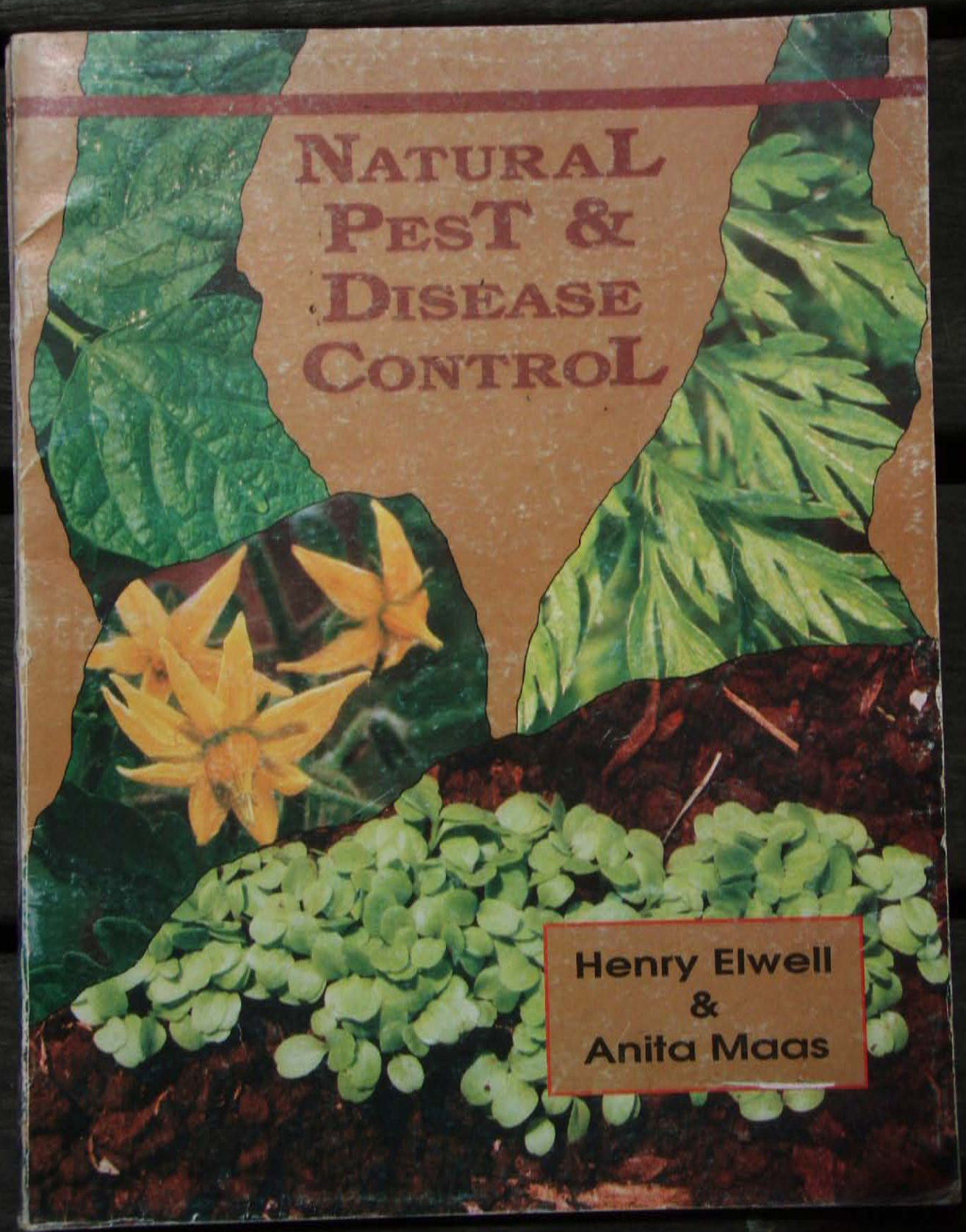
NATURAL
PEST &
DISEASE
CONTROL
Henry Elwell
&
Anita Maas

NOTE FROM THE AUTHORS

Over the decades much valuable information on this important subject has been lost simply for lack of systematic compilation of the experiences of practising farmers and gardeners. We hope that research and publications like this one will prevent this waste in future. This is an ongoing task and we would welcome any information or suggestions that readers may have which will help to make future editions more comprehensive.

Users are also invited to record their own experiences in line with the format adopted in this book and to forward the information to the Natural Farming Network Zimbabwe, P.O. Box 8515, Causeway, Harare, Zimbabwe.

Please note that every effort has been made to make the translations of plant names into the vernaculars as accurate and useful as possible. Names have been omitted when there appeared to be any risk of confusion or any doubt. However, despite this, we realise that ambiguities due to local variations may still occur.

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THE PLANT PROTECTION IMPROVEMENT PROGRAMME

The Plant Protection Improvement Programme (PPIP) supports the development and use of appropriate and sustainable crop protection methods for small-scale farmers in Southern and East Africa. Activities include research, training and extension. PPIP is funded by the Swedish International Development Authority (SIDA).

THE NATURAL FARMING NETWORK

The Natural Farming Network is a network of twelve development agencies co-operating to promote sustainable agriculture in Zimbabwe. The network provides training and technical assistance to staff of member groups and to farmers and groups of farmers identified by members. The network core programme is funded by W.K. Kellogg Foundation, USA and NOVIB, The Netherlands.

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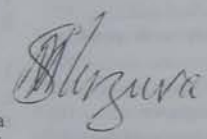
Preface

The Natural Farming Network is proud to present as the first in a series of publications this landmark book by Henry Elwell and Anita Maas. There is a great deal of advocacy of biological pest management but the information is not always there to back it up. With the availability of this book, trainers and farmers in the region will have access to a wealth of information with which to experiment in particular ecosystems.

The Natural Farming Network and the authors are grateful to a number of people. Robert Fugere, Director of the Interchurch Fund for International Development, Canada had sufficient faith in the project to provide the initial grant for the basic research. Johan Morner of the Plant Protection Improvement Programme, Swedish University of Agricultural Sciences, provided for translation of the plant names into appropriate languages and the funds to print copies for Botswana, Tanzania and Zambia as well as Zimbabwe.



N.S.Muzuva
DIRECTOR
Natural Farming Network

PART I

THE FOUNDATIONS OF PEST AND DISEASE CONTROL

Introduction

There were four main reasons for writing this book:

- Insect pests are responsible for 20–30 per cent of the crop being destroyed.
- There are many safe, natural and simple methods of protecting plants.
- In the long term, modern chemical pesticides increase the pest and disease problem. They do not solve it.
- Modern chemical pesticides are poisonous. They are harmful to human health and destroy the on-farm and wider environment.

Farmers and gardeners alike should find this book appropriate and useful because it provides welcome, environmentally safe alternatives to replace agro-chemicals. Also, the information available within its pages offers a way out for those land users who currently have no means of controlling pests and disease which destroy large proportions, if not all, of their crops every year.

Communal or small-scale farmers and their advisors will be particularly interested in the information offered in this book. When communal farmers can afford dangerous chemicals they, their children and their farms are at great risk; and when they cannot afford them, they must often stand by helplessly and watch their crops being destroyed by pests and diseases. We hope that anyone involved in advising communal farmers will be able to extract the relevant information and present it to their audience in a more accessible form than is possible in a work of this nature.

The information in Part I of this book is of international interest, the principles and methods being universally applicable. The same comment is valid for the miscellaneous substances and materials detailed in Part III Section A. The vegetative types selected in Part III Section 1 are also widely grown; whereas the plant species in Part III Sections 2, 3 and 4 are particularly relevant to southern and central Africa.

The Natural Order

The soil and the air above it are teeming with life, both visible and microscopic. The existence of every single one of these life forms is essential to the natural order.

These forms of life are dependent upon each other for food, for mutual support and to develop competitive strength. They work together to produce an environment beneficial to their own existence and that of all other life forms, including human life. It can be said that without insects there would be no plants and we would not exist.

So in the natural order, all forms of life (insects, plants, animals and people) co-exist to mutual benefit, in mutual harmony and in perfect balance.

In such a situation insect numbers and types are controlled naturally, soil fertility is at its maximum potential, plant growth is vigorous and we reap the benefit of living in a healthy and supportive environment.

We have grossly under-estimated the importance of maintaining this natural order. Many current agricultural methods, particularly annual ploughing, burning, monocropping and the use of agro-chemicals, destroy this harmony. These methods reduce the numbers of some insects while encouraging others to increase and spread.

Pesticides were developed to combat the increased incidence of problem insects. Agro-chemicals appeared to work well but it soon became apparent that the chemicals were often more effective against the predators of the pest than against the pests themselves. Pest numbers increased. Worse was to follow when scientists discovered that the target pests themselves were becoming resistant to the very chemicals being used to eradicate them.

INSECTS ARE GOD-MADE. PESTS ARE MAN-MADE.

Attempts have been made to overcome these difficulties by applying stronger doses and more lethal products but pest populations have continued to increase, costs of control have escalated, the natural balance has been upset further, and greater numbers of people are now suffering from poisoning.

Regaining Control

Regaining control does not mean eliminating all members of a particular pest from our fields and gardens. A certain level of pest presence is necessary to feed the predator population. Our aim is to minimise crop damage by regulating pest numbers.

The first step in regaining control is therefore to regard nature as an ally, to learn from it and to work with it. Nature has many lessons to teach us to our benefit. Our journey will be much easier — like floating downstream instead of forever battling upstream against the current.

NATURE IS A FRIEND NOT AN ENEMY. TRY WORKING TOGETHER!

Having learnt some of the more basic lessons nature has to teach us, the next move should be to re-establish a natural order of mutual benefit to insects, plants, birds, animals and ourselves.

Befriending nature

Probably the most important lesson we have learned this century is that trying to fight nature is foolish, to co-operate is common sense. We have tried fighting with nature and found that not only do the current problems increase but it becomes more difficult to see what should be done next. When we co-operate with nature the reverse happens. Nature helps us to solve those very same problems and the way forward becomes clear.

The traditional form of agriculture once widely practised, called shifting cultivation, is a very good example of agriculture in harmony with nature. In those days farmers did not clear the land for the timber. Certain trees beneficial to society, providing fruit, medicine, wood, shade, spiritual needs and soil fertility were left untouched, while others were cut off at one metre above the ground. None of the tree roots were removed and this allowed them to re-grow quickly, returning the soil to full fertility in as short a time as possible after the farmer had moved to another piece of land. When the cut branches had dried, they were burned to clear the grass and so the ash could add fertility to the soil. The land was not ploughed but a form of zero tillage was practised, with seeds being planted into holes made with a sharp stick (later a hoe).

Several crops were planted onto the land in the same season, thus ensuring plant diversity, soil protection and soil fertility. In addition, the people had a sound knowledge of the basis of plant breeding for maintaining yield and for resistance to pests and diseases.

Prayers were offered at all important stages and a crop loss of

some 5-10% (to animals and insects) was accepted as a necessary contribution to maintaining the natural order or ecosystem. Immediately the land began to show signs of exhaustion it was allowed to rest for a lengthy period (about 20 years).

The people practising this system were clearly in harmony with nature in thought, word and deed. In those days, environmental degradation (soil erosion, soil exhaustion, pollution, loss of plant and animal species and deforestation) was unknown.

The success of this system can be judged from the fact that before writing this book a survey was carried out to record any surviving, truly indigenous, traditional knowledge on methods of pest and disease control other than the cultural methods inherent in the shifting agricultural system just described.

Although there was a little knowledge of protection of field crops against animals and birds, and some well established methods of protecting stored grain, there was a marked absence of knowledge on technologies for eradicating pests on the standing crop.

This absence of any technology for protecting field crops (although technologies had been developed for protecting grain) suggests that there was little need to protect field crops from pests and diseases under shifting agriculture. No such problems existed perhaps because the farming system did not disturb prey/predator balances.

FIGHTING WITH NATURE IS FOOLISH. CO-OPERATING IS PLAIN COMMON SENSE.

Although shifting agriculture can no longer be practised because of a shortage of land, harmony can and must be reinstated. The principles governing harmony need to be researched by scientists and practised by the land user. In the meantime we must put to good use what we already know and use our powers of observation to learn as quickly as possible.

Learning from nature

Nature has much to teach us. Nature is expert in zero tillage, in providing plant diversity, in recycling energy and nutrients through sunlight, animal wastes and vegetation, and in balancing prey/predator numbers. Our intelligence means we can learn from nature and then forge ahead to enhance natural processes for the benefit of all life forms and to make planet earth itself more fruitful.

On the general and detailed scales there is much to learn. Modern crop breeding methods to increase plant yields and for resistance to pests and diseases, biological methods of pest and disease control, and some genetic engineering initiatives, are examples of such beneficial developments. Although these technologies may be too specialised for the farmer to develop himself, there are no limits to the ways in which on-farm input-

outputs can be favourably altered through detailed observation and application of basic natural principles.

If, for instance, a plant is infested with insects, we can be sure that nature is teaching us an important lesson. We must examine our methods and determine whether the prey/predator balance has been upset or if the plant itself is less healthy than it should be.

If the plant is less healthy than it should be, examine soil fertility, the watering regime, plant hygiene (diseases), plant suitability or timeliness of planting. Look for clues from the colour and growth pattern of the plant above and below ground.

Examine the type of insect infesting the plants as this will indicate which predators are absent and should be encouraged back into the farming environment. The presence of large numbers of aphids, for example, is a sure sign that numbers of ladybirds, lacewings and hoverflies are too low.

In addition, observe the development of the insect through all its stages and note the duration and timing of each stage. This will assist in combating the insect as it can best be controlled at vulnerable stages in its life cycle. The most vulnerable stage of the maize stalk borer, for instance, is in the pupal form when it is hibernating in the bottom of the maize stalk. At this stage in its life cycle it can be eradicated very effectively by sun-drying the stalks in the field, by simply feeding the stover to livestock or by composting it.

Observe which crops are being attacked and at which times of the year as this knowledge can be used to avoid growing susceptible crops at peak pest periods.

Experiment with different crop mixtures in the same field to discover which protect each other and which do not.

All this information will lead to better selection of crop type or variety, of crop mixtures and rotations, and of time of planting.

Observe which plants, both wild and cultivated, are and are not attacked by certain insects. The ones that are not attacked may be useful for repelling those insects, whereas the ones which are attacked can be used as decoys.

Look carefully at the soil. Many and varied insects indicate a soil in good condition.

Learn what each insect, bird and animal eats, for that way we begin to understand the extent to which all life is linked and balanced. This knowledge will create within us a respect for nature which is evidently lacking at the moment.

Gradually through such observations made on our own land we develop a detailed knowledge which assists us to re-establish the natural order.

OBSERVE NATURE CLOSELY. THEREIN LIE THE ANSWERS.

Four Steps to Re-establishing the Natural Order

Ploughing or digging disturbs the balance among soil insects, fungi, viruses, bacteria and other soil life. Soil disturbance breaks up root channels and soil structural units so that the soil cannot perform its intended function. Disturbance of the soil also causes a rapid loss of organic matter upon which the crop and many soil organisms feed.

Soil is the foundation of agriculture yet on most of our lands it is at its lowest possible fertility level. In such circumstances the balance between the many and varied life forms in the soil is bound to be dangerously disturbed.

1 Re-instate soil fertility

The first step in re-establishing the natural order is therefore to reinstate the fertility of the soil by minimising soil disturbance and maximising soil organic matter.

2 Provide habitats for predators

The second step is to provide suitable natural habitats for predators and to preserve existing ones. Here agro-forestry can play an important role; and a diversity of wild plant species should be encouraged on gravelly or rocky outcrops and on field edges. There is great scope for using contour ridges for a variety of purposes: for growing fruits, firewood, fodder and trees as windbreaks, all of which will also help to re-establish the pest/predator balance.

3 Re-introduce plant diversity

The third step is to re-introduce plant diversity into the cropping system as diversity is nature's most effective way of maintaining the pest/predator balance and of ensuring continued soil fertility. In place of monocropping, farmers should consider ways of increasing plant diversity through the use of rotations, intercropping, mixed cropping, strip cropping and permaculture designs.

4 Gradually reduce agro-chemicals

The fourth step is to gradually reduce the amounts of agro-chemicals used as fertilizers, herbicides, insecticides and fungicides. Substitute organic matter and manure in place of mineral fertilizer; use rotations, underplanting and mechanical cultivations in place of herbicides; and adopt the methods recommended in the rest of this book to replace the harmful chemicals currently used for pest and disease control.

1
REINSTATE THE FERTILITY OF THE SOIL
2
PROVIDE AND PRESERVE NATURAL HABITATS.
3
REINTRODUCE PLANT DIVERSITY.
4
USE NATURAL REMEDIES TO REPLACE AGRO-CHEMICALS.

1 Reinstate soil fertility

A healthy soil produces healthy plants and healthy plants resist attack from pests and diseases.

To improve the soil *dig less, mulch more* and *compost always*.

i DIG LESS

LOOK AFTER THE SOIL AND IT WILL LOOK AFTER YOU.

Start by digging deeply to break up surface compaction, to remove hard layers in the soil profile and to incorporate initial compost applications. In subsequent years, disturb the soil as little as possible. Rely on crop roots, insect life and surface mulch to maintain the soil in good condition. Occasional digging, ripping, fork lifting or ploughing may be necessary in the initial stages until the soil structure has improved sufficiently; or if the soil has become compact due to foot, wheel or hoof movement when the surface is moist.

Soil fertility and organic matter content can be improved by growing more leguminous crops. Certain legumes can serve several useful purposes. Cowpea, for example, will not only improve soil fertility, structure and permeability but also produces edible leaves and beans.

The initial application of compost can be incorporated into the soil but subsequent applications should be applied to the soil surface around the base of the plants.

ii MULCH MORE

MULCH MORE TO SAVE MOISTURE, WORK AND WORRY.

Mulching is the process of covering the soil with a layer of plant residues of varying thickness (thickness depending on the purpose of the mulch and the availability of suitable material) to conserve soil moisture, keep the surface cool, protect it from erosion, prevent the development of surface crusts, enhance infiltration, improve soil structure, minimise compaction, suppress weeds and to add nutrients to the soil through decomposition (in-situ composting).

Choose seedless materials as mulches and obtain the material from as many diverse plants and sites as possible to provide a wide range of nutrients. Mulch as heavily as possible wherever possible but first make sure the soil is in a fit condition to be mulched. If it is a wet soil, drain it first or make raised ridges or beds.

The combined effect of disturbing the soil less, of applying compost and of mulching causes soil life to flourish. Soil structure quickly improves, but needs more nitrogen during the initial stage. The yellowing leaves of the plants and reduced growth warns us that nitrogen is limited.

This condition can be rapidly corrected by watering the plants

every few weeks with liquid manures, made preferably from fresh chicken manure mixed in water. Mix liberal amounts of fresh manure in water (2 to 4 heaped handfuls to a 10 litre bucket), and water into the soil around the base of the plants. Avoid pouring water over the plant leaves as the nitrogen may burn them. The manure can be added directly to the water, stirred and applied immediately when a quick nitrogen boost is required, or put into a cloth (an old sock is ideal) and soaked in water in a closed tub for 3-7 days before use, to allow nutrients to be dissolved. During the rains, a little dry manure can be placed near the plant stem but not too close.

It is true that mulches encourage certain pests (like armoured crickets and slugs). Some people avoid mulches for that reason. But residues also discourage other pests (such as cutworm and nematodes) and do far more good than harm. Termites are thought to be a major problem but this is not the case. Certainly they are attracted by the mulch but do not attack healthy living plants when there is an abundance of residue for them to feed off. In fact the termites do considerable good to the soil by rapidly breaking the mulch down and carrying it into the soil to form organic compounds. Their tunnels improve soil aeration and thus increase the water infiltration rate. When termites are prevalent, however, mulch should be cleared from around the immediate area of the plant stems, particularly of woody plants.

Residues which are infested with pests should not be used. Such material should be put on the compost heap where the heat of composting will kill the pest, or the residue should be fed to livestock and the resultant manure used to make compost.

iii COMPOST ALWAYS

COMPOST ALWAYS FOR SOIL FERTILITY.

Compost is nature's fertilizer formed out of decomposition of plant, insect and animal residues and wastes. Applications of it are essential to maintain the soil in good structural condition so that it is fertile, easy to work, resistant to erosion and also for pest and disease control.

The key to good compost making is to collect as wide a range of suitable materials as possible: manures, crop residues, grass, leaves, weeds, and so on, to ensure a varied supply of nutrients. Sufficient manure and/or green matter must be added to create hot conditions in the heap.

The watering must also be just right. Apply only sufficient water to moisten the materials so that a drop or two of moisture (no more, no less) can be squeezed from a handful. Mix water in very thoroughly by watering and turning a small amount of the heap at a time as if mixing cement. When thoroughly moist, place

the material in a thin layer on the heap. Don't take the short-cut of placing the materials on the heap dry and then trying to water them. It never works.

Build the compost heap in the shade and near to a water supply if possible; and turn it every two weeks. Cover it with a thin layer of soil in the dry season to reduce evaporation and to minimise fly breeding.

Good quality compost can be made during the rains. Keep turning the compost after every storm until the heap is moist throughout. Cover it with a plastic sheet, thatching grass, or a dry-mud skin so that too much rainwater does not destroy the heat of composting and prevent the correct breakdown of plant materials.

The amount of compost required to obtain top yields varies from about 10–20 tonnes per hectare; 20 tonnes per hectare when the soil is unmulched and in poor structural condition and 10 tonnes per hectare when the soil is mulched and in good condition. The compost should not be broadcast but banded or spread next to the plant.

The addition of compost from field-edge heaps may be reduced considerably if plant diversity is maintained and if sufficient densely planted legumes are included in the rotation. The legumes should be selected to supply soil nitrogen, to maintain organic matter levels and to provide mulch when the plants have been slashed down. This is often called 'sheet composting'.

2 Provide natural habitats for predators

Removal of the natural vegetation on farms and around gardens has greatly disturbed the pest/predator balance. Nationwide the essential food supplies of birds, animals and insects have been reduced to the extent that they have no option but to feed off the crops. Very often the natural vegetation has been so depleted by deforestation and overgrazing that the cropland offers the only source of food.

ENCOURAGE A NATURAL HABITAT ON UNUSED AREAS.

The opportunity for encouraging the natural habitat to re-establish on unused areas such as field edges, rocky or gravelly outcrops and elsewhere on farms is very great indeed. The natural vegetation will normally re-establish itself on these areas if allowed to do so; but by careful selection of trees, shrubs and grasses in these locations this unused land can be made even more productive.

ESTABLISH SHELTER BELTS OF TREES AROUND FARM FIELDS.

Shelter belts of mixtures of indigenous trees around farm fields or on stony areas in the fields will do much to protect the lands from drying winds, provide wood for fuel and building purposes and habitats for insect predators.

Similarly, there is great scope for increasing production by growing fruit and fodder trees, shrubs and grasses along the contour banks. The trees will act as wind breaks, provide firewood and encourage the predators into the lands, particularly bird life. Certain indigenous trees should also be encouraged to grow on the contour banks. Choose trees or shrubs (whether indigenous or exotic) carefully, avoiding those with shallow, spreading roots likely to compete with the crop. In many of the dry parts of the world, shelter belts have been found to dramatically increase crop yields by reducing evaporation rates.

FULLY USE CONTOUR BANKS.

3 Re-introduce plant diversity

One major cause of soil exhaustion is that too many grains are being grown and too few legumes. In addition, the inclusion of too much white flour in our diet (like maize and wheat) causes constipation, sluggishness and stomach complaints. The area under grain crops could be reduced with benefits to both soil conservation and human health!

When the same crop is planted on the same piece of land year after year, the soil suffers from constant removal of specific nutrients and pests and diseases build up. For example, stalk borer and red spider mite numbers build up rapidly in maize and tomato (or cotton) fields respectively when these crops are grown continuously.

This happens simply because the law of plant diversity has been ignored. Each specific insect flourishes because the host crop provides an abundant food supply and continuous shelter for it. The situation is worsened by chemical spraying programmes which eradicate the natural predators of the pests.

The law of plant diversity says that there should be a wide variety of different plants on the land at any one time. Violation of this law brings swift repercussions particularly in the tropics and subtropics.

We have only to look at nature to see how this works, how each plant supports and protects its neighbour. In the undisturbed bush on the edges of the cropped area we find plants of every kind and height living harmoniously together. Here and there a plant may have some insects on it but the predators are also evident in sufficient numbers to prevent an outbreak.

Each plant of one kind is separated from another of the same kind so that insects on one plant cannot easily get to the other. The space between them is filled with other plants, all of which protect each other in some way either by acting as physical barriers or by repelling the insects through the aroma released by their leaves, flowers or roots. This is happening both above and

below ground with the roots acting as repellants or barriers to keep soil-borne pests and diseases in check.

In addition, each plant helps to create an entire habitat (moisture, organic matter, nutrients, insect life, wind protection, and so on) suited to the production of the maximum amount of plant material at that place.

Scientists say that there is also an element of competition between the plants for moisture, sunlight and nutrients. But in virgin bush such competition is healthy and favours the growth and reproduction of strong plants of each type and represses the weaker specimens. The competition becomes 'unhealthy' only when plants of the same species are grown together as a field crop or when two or more poorly matched plants are put close together. This does not happen in nature.

Research has found that plant diversity decreases the number of harmful insect species while at the same time attracting a greater number of enemies of the existing pests; and that one plant protects another different type of plant by obscuring that plant's shape and odour so that the pests cannot easily find it. Also, on the whole, plant diversity has been found to reduce the incidence of plant diseases.

Let us now look at some of the ways nature's plant diversity can be imitated.

i ROTATIONS

Rotation should be considered as the first step towards providing the necessary plant diversity. A rotation is a sequence of different crops grown on the same field one after the other.

For example, a three-year, rain-fed rotation may consist of maize–soyabean–finger millet or rape–green maize–tomatoes in a vegetable garden.

Rotational sequences were once chosen with the purpose not only of minimising pests and diseases but also of improving soil fertility and preventing erosion. However, in recent years, the needs for fertility and erosion prevention have been pushed aside and when rotations are practised, they are selected for pest and disease control only. The need to emphasise pest control is yet another indication of the extent to which modern agricultural practices have upset the natural pest/predator balance. This over-emphasis on pests and diseases can be corrected once some positive steps towards restoring the balance have been taken.

Pay more attention to including legumes, fodder crops and weed fallows in rotations to provide the combined benefits of soil fertility, erosion control and sustained food production. The value of weed fallows for all these purposes, including pest and

GROW MORE LEGUMES AND LESS GRAINS.

ROTATIONS ARE THE FIRST STEP TOWARDS PLANT DIVERSITY.

disease control, has been grossly under-estimated in the past. This is largely because soil fertility is currently so poor (because of the annual ploughing/chemical farming approach) that growth on weed fallows has been impoverished.

ii MIXED CROPPING

In mixed cropping, planting diversity in any one year is increased by growing several plants on the same land at the same time. The types of plants which grow well together are carefully chosen, for example in the maize–soyabean–finger millet rotation mentioned in the previous section, the maize rows (with normal spacing between rows unaltered) may be underplanted with pumpkin and cowpeas.

Apart from pest and disease control benefits, mixed cropping minimises the risk of total crop failure, suppresses weeds, protects the soil and improves the amount of organic matter in the system.

One old variation was to mix the seed of the different plants together in the correct proportions and broadcast them. This method avoids continuous rows of the same kind of plant down which pests and diseases can readily travel but is not suited to farms which rely on machines for planting, weeding and harvesting.

Our ancestors had a great deal of knowledge of plant combinations which protected each other. Most of this knowledge has

MIXED CROPPING: PUMPKIN–COWPEA–MAIZE

been lost but in recent years researchers have become aware of the value of this skill and are gathering the relevant information together. Some combinations which have been found to reduce crop losses to pests and diseases are: cowpea with cassava or sorghum; maize with sunflower, potato and mustard; okra with tomato, ginger and mung bean; kale with tomato and tobacco; pumpkin, okra, cowpea, bambara nut, melons and watermelons with maize, sorghum or millet; maize and cowpea; and cotton with cowpea, maize or sorghum. Nematode damage on citrus trees has been reduced by planting legumes underneath (cowpea being mentioned in particular); and fruit trees have been protected from the same pest by planting acacia trees nearby.

Even mixing together varieties of the same crop has been found to reduce crop losses to pests and diseases.

Lantana, cosmos, caryopteris, marigolds, asters, chrysanthemums, garlic, tomatoes, onions and most herbs, are known to protect other plants.

iii INTERCROPPING

Intercropping is similar to mixed cropping except that the chosen crops are planted in alternate rows, sometimes in pairs of rows. The wide spacing between the rows of plants of the same kind give some protection from the spread of insects but pests can still travel

INTERCROPPING: MAIZE–SUGAR BEANS

easily along the crop rows. Nevertheless intercropping has been found to reduce crop losses compared to monocropping. For instance, intercropping maize with cowpea has been found to reduce the incidence of legume pod borer on the cowpea. Similarly, insect damage on cotton has been reduced by intercropping cotton with cowpea, maize or sorghum; and certain beans have been found to reduce powdery mildew on cassava, while the cassava protects the beans from angular leaf spot.

iv STRIP CROPPING

The advantages of rotations, mixed cropping and intercropping have been combined in a new system called no-till strip-cropping.

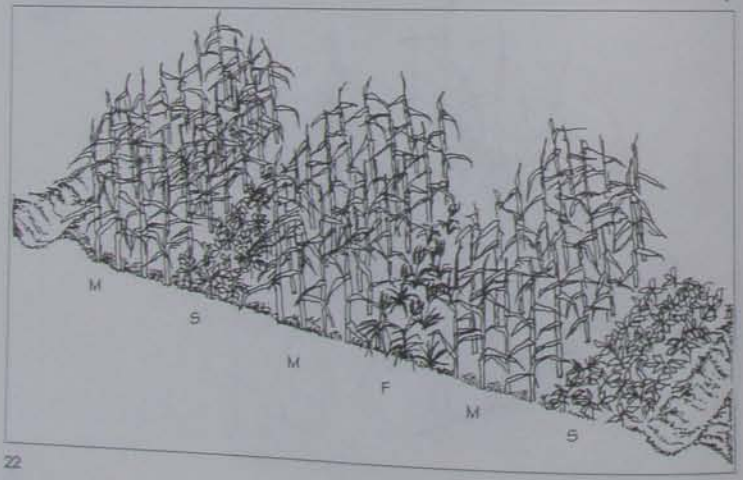
In this system no ploughing is done. A scratch mark 50mm deep is made to plant the row crop (e.g. maize) and the underplanted crop (e.g. pumpkin, cowpea, dolichos lab lab) is put into a hoe-hole positioned between rows.

Plant diversity is increased by having the entire rotation on the field at the same time laid out in strips along the contour, between each pair of contour ridges.

A rotation of maize-soyabean-finger millet is shown in the sketch below as it may appear on the field in the first year. In the second year, the bottom crop moves up to the top of the field in place of the top crop and all the other strips move down-slope to make room for it.

Every year the same method is followed with the bottom strip moving up to the top of the field.

STRIP CROPPING:
M=MAIZE
S=SOYABEANS
F=FINGER MILLET



PRACTISE MIXED, INTER & STRIP CROPPING.

In this way, not only does the entire rotation appear on the field at once but each strip of soil receives a different crop from year to year.

The maize strips can be underplanted to a variety of suitable crops (like pumpkin, cowpea, watermelon, squash and beans) to increase plant diversity and to obtain all the other benefits of mixed cropping. The possibilities are almost endless. Even tomatoes have been planted successfully in maize, with the tomato plants tied up to the maize stems.

v PERMACULTURE DESIGNS

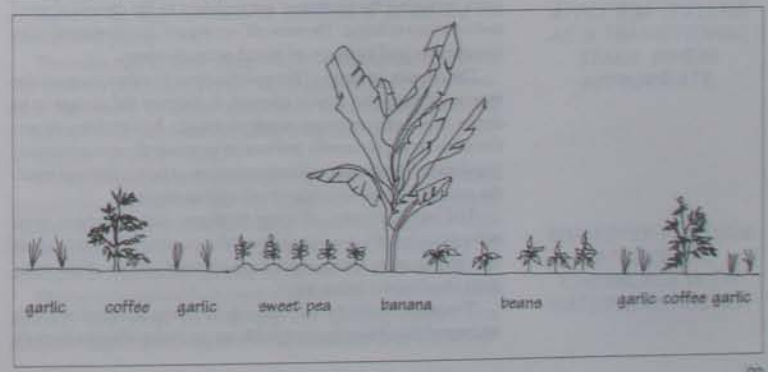
APPLY PERMACULTURE DESIGNS WHERE POSSIBLE.

Plant diversity can be further increased by growing together a wider range of plants of varied growth habits and habitat preferences than envisaged under any of the previously-mentioned systems. The plants are chosen not simply because they provide food, but because they will protect the food crops from insect attack, or give the right soil condition, air temperature, sunlight and humidity to maximise production of the food crops planted among them.

Permaculture designs may include several heights (stories) of vegetation from trees to shrubs to creepers to small plants arranged so that each creates the environment required by the others. Plants requiring or tolerant of shade (like sweet potato or dust berries) are grown under the trees and shrubs, while those needing sunlight occupy the open spaces.

Care is taken not to have too many similar plants growing next to each other and to ensure sufficient numbers of multi-purpose plants for soil improvement (legumes) and protection against insects. Strong-smelling plants such as tomato, onion, garlic,

PERMACULTURE DESIGNS



marigold and so on, are planted among or around other plants such as cabbage, rape and lettuce to protect them from insect attack.

Other plants attractive to pests are deliberately grown to trap the pests.

4 Use natural remedies to replace agro-chemicals

Widespread dependence on agro-chemicals has a detrimental effect on the on-farm and off-farm ecosystems, ultimately on production levels and inputs as well as on human health and welfare.

Soluble agricultural fertilizers cause loss of soil organic matter and structure, deplete numbers of useful living organisms in the soil and encourage acidification and loss of essential trace elements. We should rely more on natural fertilizers such as organic matter and manures.

Herbicides are designed to kill off unwanted plant life on the soil surface but also destroy microscopic plant life in the soil responsible for breaking down plant residues and for maintaining the pest/predator balance. Fungi, for example, predate on nematodes. Wherever possible, weed control by mechanical cultivation, mixed cropping techniques and rotational practices (particularly growing dense cover crops) are preferable to chemical treatments.

Newly introduced insecticides are highly efficient at first in eradicating pests but the effectiveness reduces with time due to two factors. On the one hand the predators which would normally reduce insect pest numbers are themselves effectively killed off, sometimes more effectively than the target pest. Secondly, the pests surviving the treatment are resistant to the chemical used and continue to breed. The new off-spring are also resistant to the insecticides and numbers of insect pests increase.

The counter-strategy of the past has been to either increase the number of times the crop is sprayed, to increase the dosage or to devise new, costly and more potent chemicals. Research has shown that these strategies merely produce an increasingly resistant insect population. Weeds also build up resistance to herbicides and much the same strategies have been tried without success.

The ineffectiveness of these strategies can be judged from surveys such as the one which found that compared to thirty years ago crop losses to insect attack have doubled in spite of ten times more insecticides being used.

The indirect effects of insecticides on crop production levels are more difficult to assess but yields are said to have been adversely

affected by the loss of large numbers of beneficial insects involved in pollinating crops, eating pests, maintaining soil fertility and in supporting the ecosystem in general. In addition, food quality has deteriorated from contamination of the edible material.

Not only has the use of pesticides affected crop quantity and quality but one survey found that an estimated eleven million people are hospitalised each year in Africa alone due to insecticide poisoning. Also there is mounting evidence overseas that recommended levels of agro-chemicals (fertilizers, insecticides and herbicides) can lead to serious pollution of surface and groundwater supplies.

Various initiatives have been taken to reduce the dangers of insecticide use. Governments have banned many of the more poisonous chemicals and restricted the use of others to prevent further pest-resistance build-up and regulations have been tightened up. These initiatives are emergency measures and do not get to the root of the problem: the ecological damage caused by poisons over the decades.

On the more positive side, management systems are being developed to bring about significant reductions in the amounts, potency levels and frequency of insecticide use, the best known being Integrated Pest Management (IPM). So far the developed Integrated Pest Management systems are relatively sophisticated and more applicable to large-scale commercial enterprises than to small-scale subsistence farming. These systems include: more frequent use of crop rotations and leys; biological controls such as breeding and release of predators or pollinators or the deliberate spread of diseases; planting of resistant crop types and varieties; and genetic engineering techniques to introduce sterility into the pests, to improve the aggressiveness of predators or to increase the resistance of plants.

The main aim of early Integrated Pest Management systems was to lower pest control costs rather that to protect the environment but recent emphasis has shifted towards environmental protection, with pesticide use being relegated to providing back-up when all else has failed.

The development of these systems is clearly beneficial but the insecticides themselves and the Integrated Pest Management packages developed so far are rarely within the budget or skills of the small-scale farmer so an alternative, subsistence-level approach is required to entirely safeguard the environment.

This book promotes an alternative technology called 'the natural method'. It is based on observing and applying nature's own methods backed up by simple remedies available at no or low cost.

APPLY IPM SYSTEMS AS A TRANSITIONAL STAGE WHERE APPROPRIATE.

WHEREVER POSSIBLE REPLACE ALL CHEMICALS WITH NATURAL REMEDIES.

Supportive Strategies

Hygiene

Cleanliness is extremely important in preventing the spread of insects and diseases, especially diseases.

Firstly make certain that the seedbed soil does not contain harmful numbers of pests and diseases. A soil which has been treated correctly over the years will be free of them but suspect soils may be sterilised by burning branches on the prepared surface (the ash helping to fertilize the soil or it can be used in pest control), watering the ground with liquid made by crushing wild basil (ocimum canum) leaves in water, steaming the soil or solar heating the ground under plastic sheeting (Part III A29 ii).

A disease-free seedbed is essential to prevent disease outbreaks among the plants in the nursery or after transplanting them.

Seeds and transplant material should be free of pests and disease otherwise they will not only suffer themselves but will infect other plants in the field. One old tactic still in use is to store the seed with burnt cow dung or wood ash so that it is disease free at planting.

NEVER LEAVE INFECTED MATERIAL LYING AROUND.

Should outbreaks occur, all infected plant material should be removed. This material can be composted if adequate heat in the compost heap can be guaranteed, failing that it can be fed to livestock or buried well below ground. Burning the material will solve the problem too but would be a waste of valuable organic matter unless the ash can be used for insect control.

ADOPT THE GOOD HABIT OF CLEANLINESS.

Hands and tools should be cleaned after the infected plant material has been removed. If this is not done the problem will be spread to other plants. Remember also that the spores of plant diseases can be carried on clothing and footwear.

The water used for liquid manures, for sprays and infusions or for watering the plants, should be from a non-infected source. Water in which hands, tools and plants have been washed, or placed, will be infected.

Select resistant varieties

Research organisations are breeding plants resistant to specific pests and diseases. However, growers can do their own plant breeding simply by collecting the seed from healthy plants in the field which have not suffered from insects or diseases.

The seeds from these plants will produce vigorous growth and the plants growing from them will have a good chance of being

better suited to the local environment and of being more resistant to pests and diseases. Indeed, in the past, through keen observation of nature, traditional farmers have played an important part in developing varieties of crops resistant to a wide spectrum of pests and diseases. Since natural systems are dynamic and not static, selection for breeding resistance must be an on-going process, otherwise the hard-gained resistance will be lost. In the case of subsistence farmers, breeding can best be done by the farmers themselves in their own fields.

DEVELOP THE SKILL OF GROWING YOUR OWN SEED.

Timing of planting

Planting can be timed to minimise attack by pests and diseases. To do this effectively the grower needs to know the life cycles of the pests and the conditions favouring the spread of diseases.

For example, vegetable crops do better in winter than in summer because many of the pests and diseases are either dormant or less active in the cold weather. The major pest, root knot nematode, is relatively inactive at this time.

Another way of improving plant survival is to grow seedlings in protected nurseries and plant them out in the field only when they are large enough to withstand attack. Damage by snails, cutworms, beetles and hoppers can be minimised in this way.

Many insects after remaining hidden in the soil through winter and spring, emerge with the first rains. Damage to summer crops can be minimised by either establishing the crop earlier or by planting a few weeks after the rains.

TIME YOUR PLANTING TO AVOID THE PESTS.

Plant spacing

Plant spacing can be varied to some extent to hinder the spread of pests and diseases, particularly diseases.

In some cases control can be achieved by increasing the humidity of the air through growing plants closer together. The activity of certain insects, red spider mites for example, is reduced by dense planting.

On the other hand, most fungi thrive better in the humid atmosphere created between closely-grown plants and plants should be spaced further apart where fungi may be problematical.

However, in the absence of mulch, wide spacing reduces overall yield, exposes the soil to the damaging effects of erosion and sunlight and encourages weed growth. Therefore, rather than resort to wider spacing, it would be better to ensure vigorous plant growth so that the plants have maximum resistance to attack, and to control the fungi by the methods described later in this book. Diseases

PLANT CLOSE AND INSPECT THE CROP OFTEN.

especially are more easily controlled if caught in the early stage therefore regular and frequent inspections should be carried out.

Insect barriers and decoys

Plants can act as physical barriers to the movement of pests. Hedges hinder the movement of aphids into the garden; a few rows of maize can protect a bean crop against aphids; and a row of pigeon peas has been used to protect tomato, potato and cabbage crops against red spider mite.

Another approach is to trap insects on decoy plants. The decoy may consist of weeds allowed to grow in the crop or may be susceptible plants grown in rows around the food crop. The insect prefers the decoy plant and infests it, leaving the cash crop untouched. The infested plant can then be removed and composted or fed to the livestock. For example, aphids are attracted to milkweed and a food crop will be protected from attack if a few of these weeds are left to grow in the land.

Beans have been planted as decoys in rows around cabbages or cotton to protect these cash crops from red spider mite. The infested bean can then be fed to the livestock or composted or chopped up and left on the surface as a mulch. This crop serves as an ideal decoy for it provides three functions: insect control (decoy), improvement of the soil (legume) and food for livestock or material for mulching or compost.

CONSIDER USING MULTI-PURPOSE BARRIERS AND DECOYS.

Barriers and decoys can also provide suitable habitats to encourage the predators of field pests.

Encourage predators

In the early stages of establishing the natural order, there will be a deficiency of predators. Most predators will have been killed off by current farming practices and wholesale destruction of their natural habitats.

In western countries predators are bred on insect farms and sold to the farmers in bulk for them to release into their lands. This practice is spreading into Africa and elsewhere but is an unnecessary expense. Mostly these predators survive for only a short time before they are killed off by the very farming practices that eradicated them in the first place. The correct approach is to create conditions conducive to increasing existing predator numbers to levels which mean they can carry out their task of keeping crop-eating insects in check.

The value of reinstating the soil's fertility, improving plant diversity and of avoiding the use of agro-chemicals to re-

establish the natural order (and thereby increase predator numbers) has already been mentioned, as has the importance of providing diverse habitats on contour ridges, rocky outcrops and at field edges. To re-establish the natural order is perhaps the safest approach to pest control as the subjective judgement of whether a certain insect or animal is or is not beneficial is avoided.

INITIALLY ENCOURAGE AN INCREASE IN PREDATOR NUMBERS.

Many texts provide lists of beneficial creatures so that farmers can avoid killing them. The selection is often arbitrary as some eat insects at one stage of their lives and vegetation at another. Without doubt most insects are beneficial at some stage. For instance in one study of the 86,000 insects identified on farms, 76,000 were found to be friends of the farmer.

Purists might argue that all insects are beneficial since every one of them forms part of the food chain. Nevertheless it will do no harm and maybe some good to list those considered to be more beneficial than others because they play an obvious and direct role in controlling pests which feed on plants. The ones most commonly identified are: anthocorid bugs, ants, assassin bugs, bats, bees, birds, black-kneed capsids, branchid wasps, chamelions, dragon flies, dung beetles, earthworms, frogs, ground beetles, hawk moths, hedgehogs, hoverflies, ichneumon flies, lacewings, ladybirds, lizards, mice, moles, nematodes, praying mantises, spiders, stick insects and toads.

The provision of bird baths and crumb or seed trays will encourage a large variety of birds back into the neighbourhood and, provided the habitat is suitable for them, they will remain in the vicinity to do their job of keeping problem insect numbers in check.

Another important step in improving and maintaining predator numbers is to refrain from killing them for short-sighted reasons, as this is what created the problem in the first place. For example a farmer might notice that birds of prey are killing his chickens. Instead of protecting his hens with wire mesh, 'scarecrows' or tree cover, he kills the hawks and destroys their nests and habitat. Numbers of rats, mice and seed-eating birds which the hawks would have kept in check then increase and consume the farmer's grain both in the field and in storage. As a result he and his family suffer from hunger and poverty simply because he did not think carefully enough before he acted. This is only one small example.

For decades, through annual ploughing, destruction of the natural habitat, indiscriminate use of agro-chemicals and thoughtless destruction of insect life in many other ways, we have upset the delicate but beneficial balance of nature and are now suffering the consequences.

ULTIMATELY AIM TO RESTORE THE NATURAL ORDER.

Summary

LET NATURE CONTROL PESTS.

The only sensible approach is not to eliminate all pests but to restore the natural balance. Learn from nature how to maximise food production and minimise crop losses.

1 Avoid using pesticides. They are poisons. They pose grave threats to human health, upset the natural order and balance and, in the long term, cause increased crop losses.
2 Replace agro-chemicals with natural remedies.
3 Encourage predators to breed. Do not kill them. Rather provide them with suitable habitats.
4 Imitate nature by providing as much plant diversity as possible.
5 Dig less, mulch more, compost always. The basis of plant protection is to take care of the soil. A healthy soil is less likely to harbour pests and diseases at harmful levels and produces healthy crops better able to resist attack.
6 Be hygienic. Do not assist diseases by spreading them.

These are the foundation blocks of good pest and disease management. By practising them the number and severity of attacks by pests and diseases will decrease.

It is accepted, however, that infestations will occur from time to time, particularly in the early stages when growers are attempting to restore nature's balance. Do not give in to the temptation to reach for that can of insecticide or else you may well undo all the progress you have made so far.

Rather select one of the natural remedies, identified in the rest of the text, appropriate to the problem pest to be controlled. With few exceptions, these natural remedies are simple to use, safe, and cost next to nothing.

The key to success is to use even natural chemicals only in an emergency. And when you do, avoid killing off the useful predators. Therefore scout regularly, spray selectively. Learn to recognise friendly insects and encourage them to stay.

In addition, it is important to recognise that the development of any skill depends entirely on the degree of care and concentration the farmer or gardener devotes to cultivation practices: to keen observation and attention to the needs of the soil, the plants and the insect and bird life. All must be in complete harmony with the growers and so the growers' attitudes are a major factor governing the success of their attempts to co-operate with those subtle but powerful forces at the seat of all creation.

PART II

PESTS, DISEASES AND CONTROL MEASURES

The Advantages of Natural Pest and Disease Control

Major advantages to the methods of pest and disease control described in this book are:

1. It is more difficult for pests and diseases to develop resistance to combinations of plant-derived chemicals than to single synthetic chemicals.
2. Growers can choose whichever method suits them and the locality best.
3. The plant preparations and other methods described in this book are simple, easy to prepare and safer to handle than current pesticides.
4. The methods given here can be made by the growers on their home ground at little to no cost.

Most of the substances listed in this book do not give dramatic 'kills'. Indeed complete eradication of insects would disrupt the natural balance and be highly undesirable. The objective of 'control' should be merely to reduce numbers of the problem insect to levels resulting in insignificant or acceptable crop losses.

The few natural remedies that give dramatic kills can be poisonous to human beings and animals, as well as to insects and should be handled with extreme caution. For safety purposes, these remedies have been identified by the words 'See Warning' placed directly after the subheadings in Part III Section B of the text.

THE CORRECT APPROACH

The correct approach to pest and disease control is as follows:

1. Practise the techniques given in Part I.
2. Assess whether the infestation is serious enough to warrant any action or whether it is at a harmless level appropriate to the natural balance.
3. If the outbreak is considered serious enough to warrant prompt action, identify the pest concerned from the descriptions given in the following pages and apply the recommended remedies. If the pest cannot be exactly identified then identify it by its general form, for example, beetle, caterpillar, fly, eggs and so on, and use the control methods given for a similar form of insect detailed in this text.
4. Consider carefully the cause of the outbreak and using the information given in Part I as a guideline, seek out and correct the fault. Some helpful check notes are given at the end of each section dealing with specific pests.

How to use this section

This section lists the host plants of each selected pest, describes the damage done by the pest, gives its life cycle and some details to help the user identify the pest or disease. Suggestions or remedies for controlling the pest are then given. These have been drawn from the literature and from sources of local experience. Finally, check notes are provided to help the farmer avoid future outbreaks.

Unnecessary repetition has been avoided by a simple code which enables the user to find the detailed remedies given in Part III. The code consists of the Key Name (the first word in the descriptive heading), followed by the section and subsection numbers. For example, the remedy to the code **Clay etc. (A10 i)** can be found in Part III under the heading **Clay, Lime & Other Powdery Materials** given under Section **A** item **10** Subsection **i** which begins: 'Dust the fine material....'.

Before making the plant preparations detailed in Part III B, read *Guidelines for the use of botanical sprays* given immediately below the main heading, 'B Plant Materials'.

Common Pests

AMERICAN BOLLWORM (*HELIOTHIS ARMIGERA*)

Host Plants

Barley, beans, brinjals, coffee, cotton, crucifers, cucurbits, garden flowers, grapes, groundnuts, lucerne, maize, peas, potatoes, sorghum, soyabean, sunflowers, tobacco, tomatoes, wheat, citrus and deciduous fruit trees.

Damage

The Heliothis bollworm larvae feed on the buds and young bolls of the cotton plant. It is capable of destroying the entire crop if not controlled. The caterpillars also feed on the buds, blossoms and fruit of a wide variety of plants, particularly those listed above. Very young fruit may be completely destroyed while large holes may be eaten into mature fruit.

Life cycle

The female moth lives for 3 weeks and lays up to 1500 eggs on the leaves, buds and flowers of host plants. The small whitish-yellow eggs are laid only at night. They hatch in 3–6 days into caterpillars which live for approximately 3 weeks in warm weather passing through 5 stages. The caterpillars then drop to the ground to form pupae which live for 2–3 weeks in the ground before developing into moths. Lacewing larvae and spiders predate on the bollworm.

Identification

The caterpillars vary in colour, being dark beige when young but later becoming green, brown or even reddish pink. They grow to about 35mm long and have a characteristic pale yellow longitudinal stripe down each side.

AMERICAN BOLLWORM

RECOMMENDED REMEDIES

Moths: Aromatic plants (A1); Biological (A4 i); Light traps: Various insects (C17 i); Repellant sprays (B6). The bodies of the moths caught in the light traps (Various insects: C17) can be used as a biological spray (A4 i).

Eggs: Ash (A2 i, ix, x, xi); Clay etc (A10 i, v); Hand picking (A15 ii); Oil-mineral (A21 i); Pyrethrum (B 1.6); Tobacco (B 1.17); Rain tree (B 2.19); Cork bush (B 2.20); Tephrosia (B 2.26).

Caterpillars: Biological (A4 i, ii); Glues (A13); Hand picking (A15 i); Hens etc. (A16); Oil-mineral (A21 i — see warning); Potassium permanganate (A22); Salt preparations (A23 ii); Smoke etc. (A24 i); Soap solutions (A25 ii); Insecticidal plants (B5).

Of the above, Hand picking and Hens are likely to be the most appropriate for removing caterpillars from small areas; while for larger

areas, Mineral oil and Potassium permanganate may be more suitable. In addition, for both large and small areas, out of the insecticidal plants listed under B5 useful sprays can be made particularly out of Pyrethrum (B 1.6), Tobacco (B 1.17), Cork bush (B 2.20), the Rain tree (B 2.19) and Tephrosia (B 2.26).

Pupae: Hens etc. (A16) to dig the pupae from the soil; and strong sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), Cork bush (B 2.20), the Rain tree (B 2.19) and Tephrosia (B 2.26) should prove useful.

Checks

Ensure an adequate habitat for owls, nightjars, bats and other night creatures that predate on the moth; and for birds that will feed on the caterpillars during the day. Many other insects feed on the eggs and larvae of this pest so encourage as wide a range as possible of insect life both above and below ground. Plant diversity is also vital.

ANTS (*FORMICIDAE*)

Host

Honeydew and insects.

Damage

The small black ants which encourage aphids are those which most interest the farmer or gardener. They are attracted to the honeydew produced by the aphid and are said to transport young aphids from one location to another thereby spreading diseases carried by the aphids. The ants also scare away predators. Many other species of ants assist the gardener by killing off insect pests such as cutworm, stalk borer, spider mites, termites and many others.

ANTS

Life cycle

Ants are small insects which nest underground, usually making use of existing cavities under rocks and among roots. A colony consists of a king and a queen and a large number of workers. The queen lays clusters of small, white eggs which are then moved to safe locations by the workers. In addition to feeding on the honeydew secreted by aphid and scale insects, ants feed on a wide variety of other insects many of which are potential pests (like cutworms, mites, termites, slugs and snails).

Identification

All ants live in colonies. They are small, six-legged creatures with their bodies divided into three segments by two thin waists. There are between 8,000 to 14,000 different species of ants in the world. Most ants build permanent nests in the soil and have poor eyesight; however, they have a very keen sense of smell and vibration which enables them to operate in a highly efficient manner. Ants release chemicals which enable them to recognise companions from the same colony, to raise the alarm or to sting enemies.

RECOMMENDED REMEDIES

Eggs: if the ant problem has become severe, search for their nests which will be close at hand and destroy the eggs. Birds and Hens etc. (A16) will also help to control ant and egg numbers.

Ants: different species of ants respond to different treatments and, since it is almost impossible for the layman to distinguish between the thousands of species, users need to determine which of the treatments below give the best results in their circumstances.

Those with the most general application are:

Aromatic plants (A1); Biological (A4 i); Clay etc (A10 iii); Grease (A14 i or ii); Garlic (B 1.2); Chilli (B 1.4); Tomato (B 1.12); Syringa (B 1.15); Tobacco (B 1.17); Rhubarb (B 1.19); African marigold (B 1.20); Blackjack (B 2.8); Lantana (B 2.15); Lippia (B 2.17); Mexican marigold (B 2.25); Rain tree (B 2.19); Cork bush (B 2.20); Wild tobacco (B 2.22); Tephrosia (B 2.26)

The small black garden ants which harvest the aphid have been found to be most effectively deterred by a spray made from blackjack seeds or from Mexican marigold leaves. The whole Mexican marigold plant dug into the soil at planting will deter the ants from seedlings. Sprays made from the leaves of rhubarb, tomato and tephrosia will exterminate all ants.

Others mentioned in the literature are: Soyabean (B 1.10); Oleander (B 1.16); Mexican poppy (B 2.5); Wormseed (B 2.10); Sodom apple (B 2.16); Castor oil (B 2.24).

Small grains sprinkled around vegetable seeds have been found to lure red ants away from the seed which would otherwise be eaten. Penny royal and mint can be planted as barriers to prevent red ants from eating the roots of other plants.

Worth considering are general insecticides and repellants B5 and B6. Also some species of house-loving ants have been repelled effectively by baby powder and lime.

Checks

Ensure that numbers of aphids and scale insects are under control as the ants are attracted to the honeydew secreted by them.

APHIDS (*APHIDIDAE SPP*)

Host plants

Most plants, shrubs and trees, particularly the tender young shoots.

Damage

Aphids are sap feeders. In large numbers they can remove sufficient sap to kill off leaves and the growing tips. They are very important vectors of plant viruses. The honeydew they produce attracts a large number of other pests (like ants and fruit flies).

APHIDS

Life cycle

Young aphids are produced directly from the mother without the egg

stage. There are no males in the warmer areas of the world. These insects are usually wingless but will produce wings and fly to other plants when the host plant becomes overcrowded. Flying aphids can be carried long distances by the wind. Young aphids are said to be spread by the ants feeding on their honeydew. Hoverfly larvae and ladybirds are said to eat up to 250 aphids per day. Other predators are lacewing larvae, parasitic wasps, the praying mantis and small birds.

Identification

Adult aphids are only a few millimetres long. They are round and plump and the colour of each species is different, varying from yellow, green, brown, grey, white and black. The woolly aphid looks like a small piece of cottonwool. All species tend to cluster close together on the tender parts of the plant. They are soft-bodied and can be squashed easily with the fingers. Aphids form wings only when they are overcrowded and need to migrate.

RECOMMENDED REMEDIES

Growers are strongly recommended to grow healthy plants and to use compost in preference to manures, including liquid manures. Healthy plants develop their own in-built resistance to aphid attack.

Manures and mineral (artificial) fertilizers, particularly nitrates, produce sappy and fleshy plant tissue attractive to aphids.

Aphids can be controlled successfully by increasing plant diversity on the land particularly by mixed, inter and strip cropping, and by Permaculture designs (see *Part I, 3 Re-introduce plant diversity ii, iii, iv, v)*; and by trap cropping and barriers (see *Part I, Supportive strategies*).

Garlic, chives, marigold, nasturtiums, parsley, onions and many herbs grown as companion plants are said to repel certain species of aphid, particularly greenfly. Nasturtiums grown as companion plants are recommended for repelling woolly aphid or as a spray to kill them, and pigeon pea is said to repel green and grey aphids.

Milkweed, sowthistle and black nightshade are good trap or decoy plants to attract aphids away from the main crop.

Supplementary measures

Because aphids prefer young tender shoots, take care to ensure concentrations of the natural remedies do not harm the plant growth. Supplementary remedies with the most general application are: Ash (A2 i, ix, xi); Clay etc. (A10 i, ii, iv, v); Manure etc. (A17 i, ii, iii), Oil-mineral (A21 i); Potassium permanganate (A22); Salt preparations (A 23 i, ii); Soap solutions (A25 i, iii); Vinegar (A30); Water (A31 i); Garlic (B 1.2); Chilli (B 1.4); Pyrethrum (B 1.6); Sweet potato (B 1.11); Tomato (B 1.12); Tobacco (B 1.17); Sweet basil (B 1.18); Annona squamosa (B 2.3); Custard apple (B 2.4); Blackjack (B 2.8); Lantana (B 2.15); Lippia (B 2.17); Wild basil (B 2.23); Mexican marigold (B 2.25); Tephrosia (B 2.26); Leadwood (B 4.9); Cucumis anguria (B 7.1); African sandalwood (B 7.2); Various insects (C17 iii).

Aphids and ants go together. Ants are said to spread the aphids and to scare off predators. The key to controlling aphids is to get rid of the ants as well. Thus the best control is usually given by clay and lime sprays, blackjack seeds or Lippia, Mexican marigold, rhubarb, tomato and Tephrosia leaves (see also *Ants*).

Tobacco in dust and liquid spray forms is said to be effective.

Others mentioned in the literature are:

Glues (A13); Onion (B 1.1); Tea (B 1.3); Pawpaw (B 1.5); Soyabean (B 1.10); Cassava (B 1.13); Feverfew (B 1.14); Syringa (B 1.15); Rhubarb (B 1.19); Catunaregam (B 2.9); Rubber hedge (B 2.13); God's tobacco (B 2.18); Castor oil (B 2.24); Plant mixtures (B 3.1 to 3.6).

A strong solution of onions poured around carrots, lettuce, parsley, green beans and groundnuts when the soil is moist is said to protect them from root aphid.

Worth considering are general insecticides and repellants B5 and B6.

Checks

The presence of large numbers of aphids on a plant is an indication that the plant is not healthy. Ensure that the plants are strengthened by applying the right quantity, quality and frequency of compost and water to the soil. Check the soil for phosphorus deficiency. Also ensure that the plants are grown from good seed and show a vigorous growth right from the start. Feed them with Compost (A12 i) rather than Manure etc. (A17 i, viii) foliar sprays. Encourage the presence of hoverfly, praying mantis, spiders and ladybirds.

ARMYWORM (*SPODOPTERA EXEMPTA*)

Host Plants

Barley, oats, wheat, sugar cane and grasses/pastures, citrus, deciduous fruit trees and grapes, beans, brinjals, cotton, crucifers, cucurbits, ground-nuts, maize, millets, peas, potatoes, sorghum, soyabean, tomatoes and flowers.

ARMYWORM

Damage

A major pest in outbreak years, these caterpillars move in swarms and can do great damage to crops and grassland. They feed mainly on the grass family of plants but will eat any green plant material when hungry, including cotton bolls. They move and feed during the day and at night.

Life cycle

The parent insect is an inconspicuous night-flying moth with brown marked forewings and off-white hindwings. The eggs are laid in clumps of about 200 or more on food plants on the underside of the leaves (grasses and millets, being preferred) and are covered with down from the body of the mother. The eggs hatch in 3 to 4 days. There are 5–6 caterpillar stages; development is completed in about 18–21 days in summer. The caterpillars occur in two forms: the

gregarious outbreak phase, which feed voraciously, and the solitary phase, which feed less heavily. In the solitary phase the caterpillars occur in small numbers, are sluggish, do little damage and can be found feeding at the base of plants of the grass family. A feature of the gregarious phase outbreaks is their unexpected suddenness. Large areas may be found to harbour swarms of caterpillars virtually overnight. When fully grown to about 25mm, the caterpillar enters the soil, constructs a thin-walled earthen cell and pupates for 12–14 days. The whole life cycle from egg to adult moth may be completed in a little over a month. After a single generation has come and gone, an infected area may be clear of them as the moths migrate once their food source has been depleted. In this way, from generation to generation, they may migrate long distances. Many birds eat the caterpillars while flies and wasps parasitise the caterpillars, eggs and pupae. Ladybirds are said to eat armyworm eggs. Guinea fowl are particularly good predators.

Identification

The armyworm is a caterpillar which crawls over the surface of the ground. They may occur in vast numbers (gregarious phase) mostly in December or January and less often up to April. The young caterpillars are smooth and vary considerably in colour. In the gregarious phase the young caterpillar is greyish-green, becoming black above with thin blue lines down the middle of the back; and several yellow lines along the sides. The underparts are mostly apple green. They have the tendency to drop to the ground when disturbed. In the solitary phase the caterpillars are greenish or brownish in colour.

RECOMMENDED REMEDIES

With armyworm perhaps more than with any other pest it is vital to keep numbers down to a minimum at all stages of the life cycle. Thus, ensure an adequate habitat for owls, nightjars, bats and other night creatures that predate on the moth; and for birds that will feed on the caterpillars and pupae during the day. Many other insects feed on the eggs and larva of this pest, so encourage as wide a range as possible of insect life both above and below ground. Plant diversity is also vital.

Low value grain crops like finger millet can be used as trap crops which can be destroyed along with the armyworm infesting it. This is perhaps a more preferable strategy than keeping the lands free of all host plants including weeds (as recommended in some texts) because the hungry caterpillars will attack almost any green plant in the absence of their preferred food.

Interplanting with stagger weed, a minty legume, has been found effective.

Regular and careful scouting can reveal eggs and young caterpillars on the field edges or on the contour banks. If the grass is thick enough there may be sufficient food off the arable land for it to

complete its life cycle without damaging the crop. To prevent future problems, however, the armyworm should be destroyed by any of the supplementary methods outlined below.

The two most important preventive measures are :

1 Avoid burning the grassland at all costs.

Burning the veld in winter not only degrades the soil and grass in the long term, but also is a prime cause of outbreaks of large swarms. As soon as the temperatures begin to rise, eggs are laid in very large numbers on the fresh new grass sprouting from the burned veld.

2 Avoid overgrazing

Overgrazing in summer removes the natural food store of the caterpillar and it has then no option but to invade cropland in search of food and habitat.

Supplementary measures

Moths: Aromatic plants (A1); Biological (A4 i); Light traps: Various insects (C17 i); Repellant sprays (B6).

The bodies of the moths caught in the light traps (Various insects: C17) can be used as a Biological repellant (A4 i) spray.

Eggs: Ash (A2 ix, x, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Oil–mineral (A21 i); Pyrethrum (B 1.6); Tobacco (B 1.17); Rain tree (B 2.19); Cork bush (B 2.20); Tephrosia (B 2.26). Make sure to spray under the leaves.

Caterpillars: Biological (A4 i, ii); Soap solutions (A 25 ii); Garlic (B 1.2); Syringa (B1.15); Clausena (B 4.8) and Trenching (C1) have been particularly mentioned in the literature. But Glues (A13); Hand picking (A15 i); Hens etc. (A16); Oil (A21 i, ii — see warning); Potassium permanganate (A22); Salt preparations (A23 ii); Smoke etc. (A24 i); and plants listed as Insecticidal (B5) are other possibles, particularly sprays made from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B. 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Of the above, Hand picking and Hens are likely to be the most appropriate for small numbers of caterpillars, removal of which will prevent swarms in future. The caterpillars vary in colour when there are only one or two of them, being greenish or brownish.

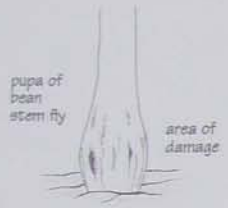
When the caterpillars are moving in large swarms it is important to stop the swarms before they reach the arable land.

The following measures are highly recommended: spraying with vegetable oils (away from the crop) or mineral oil (on or near to the crop); liberally dusting the caterpillars and their food with lime; since many diseased specimens can be found trailing behind a large swarm, Biological sprays (A4 ii) to spread the disease are a useful alternative; Trenching (C1) can be applied as an additional emergency measure along with crushing them underfoot, repeatedly driving animal herds over the swarm, beating them with stiff branches, setting fire to the grassland if it is dry enough, or setting fire to dry grass and branches placed over them.

Pupae: Hens etc. (A16) to dig the pupae from the soil; and strong sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26), should prove useful when watered thoroughly into the soil.

Checks
Check that as many preventive measures as possible have been implemented to prevent swarms: unburnt grassland, no overgrazing and restoration of the pest/predator balance. Take steps to eradicate small infestations as these are the origin of future swarms.

BEAN STEM MAGGOT OR BEAN FLY (*OPHIOMYIA PHASEOLI*)



BEAN STEM MAGGOT

egg-laying bean fly

Host Plants
The maggots attack beans of various species (french, haricot, dolichos and ration) and other leguminous plants.

Damage
Young plants can be seen wilting and dying off. Investigation will reveal decayed, swollen and hollow stems at ground level with a small maggot inside. The leaves of the plant may show yellow spots where the adult (fly) has laid her eggs. On mature plants the grub may be located higher up the stem. Velvet beans (*mucuna*) are not attacked. No major attacks on cowpeas have been reported.

Life cycle
The female is a tiny black fly which pierces holes in the leaves of the plants and lays eggs inside the tissues. The eggs hatch in 2–4 days. The maggots eat their way down the stem to just above ground level. There they complete their development. The grown maggots then pupate and become adult flies in about 20 days. Under favourable conditions, the entire life cycle from egg to fly takes 21 days. Many of the insects spend winter as pupae and emerge as adults in November. The greatest damage is caused from November to January inclusive. A parasitic wasp called Opius liogaster can suppress the pest from February onwards.

Identification
The best way to identify the insect causing the damage is through the type of damage: wilting of the plant with hollowing and rotting of the stem at ground level and the presence of the maggot or pupa in the stems. However, early warning of the presence of this pest is given by the presence of yellow blotches on the leaves forming around small punctures made by the fly when it laid its eggs.

RECOMMENDED REMEDIES

The old saying that prevention is better than cure applies well to this pest. The best approach is to prevent the fly from laying its eggs by companion planting with aromatic plants, mixed cropping, or by routine spraying with repellants made from aromatic plants; or by

planting outside the period November–January. Planting very early in summer will avoid the worst period for attacks.

An old remedy is to build up the soil around the plant stems to encourage roots to form above the already damaged part at original ground level but this is a 'rather-too-late' tactic.

Supplementary measures
Fly stage repellants: Manure etc. (A17 ii); Garlic (B 1.2); Tomato (B 1.12); Goat weed (B 2.2); Apple of Peru (B 2.21); Mexican marigold (B 2.25).
Fly stage predators: fly numbers can be dramatically reduced by bird life so encourage birds with a bird bath and seed tray; Hens etc. (A16) will also do their part if allowed to roam through the arable areas. Bantams are particularly fond of insects and although they may peck occasionally at leaves, they do far more good than harm during summer when insects are plentiful. Nevertheless do not give them access to seedlings.
Eggs: Ash (A2 ix, x, xi); Clay etc. (A10 i, v); Oil-mineral (A21 i); Pyrethrum (B 1.6); Tobacco (B 1.17); Rain tree (B 2.19); Cork bush (B 2.20); Tephrosia (B 2.26).
Maggots and pupae: because the maggot burrows into the plant material as soon as it has hatched, it is not possible to treat it directly; however, future numbers of the fly can be reduced effectively by taking off and destroying leaves showing the yellow blotches where the fly has laid its eggs. This should be done by pinching through the leaf stem as close to the main stem as possible, thus intercepting the maggot before it has had time to reach the main stem. In addition, remove and burn all plants which show signs of serious stem damage from maggots. Also the stems of damaged plants should not be left in the field over winter otherwise the pupae will survive, but should be composted or fed to livestock.

Checks
Ensure an adequate habitat for bird life that predate on the fly and that there is a wide variety of insects to predate on the eggs, maggots and pupae. Have you given enough thought to planting date, rotations and to planting resistant varieties? Some local cowpea cultivars can tolerate this pest by thickening the undamaged strands of tissue in their stems.

BEETLES — BLISTER: (*MYLABRIS SPP*).

BEETLES—BLISTER

Host Plants
Beans, groundnuts, maize, peaches, peas and a wide range of garden flowers.

Damage
The beetles destroy the flowers of plants, especially on the pea and bean family, thus preventing pods and fruit from forming. They have been recorded attacking maize silks and tassels. They are beneficial,

however, in the pre-adult phases as they eat the eggs of locusts and grasshoppers. The large colourful CMR beetle is about the best known blister beetle.

Life Cycle
Blister beetles are common throughout Africa. There are many different species but they are all rather large, varying from 20–50mm in length. The female lays about 20–30 large, oval, white eggs in hard, dry soil. She lays the eggs in batches in different sites until she has exhausted her supply, whereupon she dies. The eggs hatch in 3–4 weeks into tiny, active, six-legged larvae 1.5mm long, white with a large head and two large bristles on the tail. These larvae run over the surface of the soil seeking places where locusts and grasshoppers have laid their eggs. They then burrow down to the eggs and spend the rest of their lives feeding off them. Having found the egg store, a larva sheds its skin turning into a fat white maggot with very short legs. It continues to feed on the locust or grasshopper eggs and grows rapidly. Towards the end of summer it becomes an inert larva and passes the winter in this state. The skin of the larva is tough and white and its short legs are still evident. It sheds its skin once more when summer arrives, eats some more of the eggs and darkens in colour. In 3-4 weeks it sheds its skin for the last time and emerges from the soil as an adult beetle.

Identification
These large, colourful beetles can be seen eating flowers during the summer months and can be identified readily from their large size (20-50mm) and bright colours. Most of the beetles are black and yellow, black and red or all black. They walk and fly deliberately. A chemical in their bodies blisters the skin. They may also be readily identified in the active juvenile stage when running over the surface of the ground, or in the inert larval stage when resting in the soil.

RECOMMENDED REMEDIES

Beetles: these large beetles, not usually appearing in large numbers together, are best treated by simple methods: Aromatic (A1) to repel them; Biological (A 4 i); Hand picking (A15 i); Beetles (C3) and (C4); Blister (C6). Hens usually avoid them.

Hand picking (wear gloves) or trapping usually prove sufficient. The CMR beetle is said to be particularly attracted to blue and red colours.

Eggs: mulches, cover crops and keeping the soil surface damp all discourage egg laying but farmers should avoid destroying the eggs as the larvae are very helpful.

Larvae: do not destroy as they do much good — see *life cycle*.

Checks
These insects are beneficial on the whole and efforts should be made to provide alternative habitats for them such as flowering borders to

the fields, trap crops etc. When they invade the crop do not destroy all of them but keep numbers in check.

BEETLES — LEAF (*CHRYSOMELIDAE*)

Host Plants
Apples, cowpeas, creepers, gooseberries, sunnhemp and a variety of garden plants.

Damage
These beetles skeletonise the leaves leaving only the main veins untouched. Others chew shot-holes in the leaves (like flea beetles). Some species such as the gooseberry beetle also eat fruit, roots or flowers. Leaf eaters often show a distinct preference for certain plants, some preferring creeping plants such as cowpea. Generally both the larva and adult beetle damage plants.

BEETLES — LEAF

Life cycle
Some types of leaf beetle lay their eggs on the leaves while others lay them in the soil. After the eggs have hatched, the grubs feed ravenously on the plant material. The larvae then pupate, again either on the leaves or in the soil and emerge later as adults. The eggs typically hatch in about 6–12 days, the larvae reach full size in about another 10–12 days and the pupa form can take a week. Five or six generations can be produced in a year.

Identification
This very large family of beetles is difficult to characterise as they vary greatly in shape and colour. However, most of them are small. They are best identified simply by observing the beetle eating the vegetation. Most are very active, smallish insects (6–9mm) which fly away rapidly when disturbed. Some are a rather ordinary colour: brown, dull yellow or black, while others, like the fool's gold beetle, are brightly coloured.

RECOMMENDED REMEDIES

Since these beetles are small and can appear in large numbers, spraying is more practical than the simpler methods recommended for the blister beetles.

Beetles: Aromatic (A1); Ash (A2 ix, xi); Biological (A4 i); Clay etc (A10 i) — particularly lime; Hens etc (A16).

Insecticides recommended in the literature as effective against various beetles are: Garlic (B 1.2); Syringa (B 1.15); Oleander (B 1.16); African marigold (B 1.20); Goat weed (B 2.2); Mexican poppy (B 2.5); Blackjack (B 2.8); Wormseed (B 2.10); Lantana (B 2.15).

* Also worth trying are any of the insecticidal plants mentioned in B5 and particularly sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Routine spraying with mixtures of repellant plants from B6 may prove a useful preventive measure.

Eggs on the leaf: Ash (A2 i, ix, x, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Oil-mineral (A21 i); any of the insecticides listed in B6 particularly those * mentioned previously for controlling the adults.
Eggs in the soil: Ash (A ii); Hens etc. (A16) to dig the eggs from the soil; and strong sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26), should prove useful when watered thoroughly into the soil.
Pupae on leaves: Ash (A2 ix, x, xi); Clay etc. (A10 i, ii, v); Hens etc. (A16); any of the insecticides listed in B6 particularly those * mentioned previously for controlling the adults.
Pupae in the soil: Ash (A2 ii); Hens etc (A16); Mulches (A19 i) aromatic; and again particularly those * mentioned above for controlling the adults.

Checks
Ensure an adequate habitat for bird life that predate on the beetles and that there is a wide variety of insects to predate on the eggs and pupae. Have you given enough thought to planting date and rotations? Tree, hedge and plant barriers will often prevent the beetles from flying into the field. For the same reason intercropped or mixed cropped plants suffer less.

BEETLES — SNOUT (*CURCULIONIDAE SPP*)

BEETLES — SNOUT

Host Plants
Apples, aloes, citrus, coffee, grapes, groundnuts, maize, millet, peaches, pears, plums, soyabeans, strawberries and many others.
Damage
The beetles of this very large family chew the edges of the leaves leaving ragged margins. The stems of young branches can be eaten causing the fruit to drop or the insects may create shallow lesions on the fruit itself. The larvae (grubs) of some species may bore into stems or bulbs, or burrow under the bark of trees causing the plants to die.

Life cycle
The life cycle of one of the maize snout beetles serves as an example. Adults emerge from the soil 4–6 weeks after the first substantial rains and feed off the edges of the leaves at night. They become sexually mature after about 10 days and batches of about 30 eggs are laid in the leaf folds. These hatch approximately one week later into tiny, white, legless grubs which drop to the ground and enter the soil where they feed on roots. The grubs hibernate in earthen cells during the winter. With the onset of the next rainy season, the grubs once again become active for about three weeks and damage the hypocotyls of recently-germinated maize plants, causing them to remain stunted and to exhibit symptoms of phosphate deficiency. The grubs then pupate in the soil, emerging as adults some two weeks later. The adults are unable to fly. They feed at night and, during the day, hide under clods of soil or in the funnels of the maize plants.

Identification
Snout beetles are part of the extremely large weevil family with 60,000 known species. There are several types of snout beetles varying in size from 5–25mm long. All have the characteristic elongated snout of the weevil family, hard bodies and dark colours: grey, brown or black. The antennae are generally short and bulbous at the end.

RECOMMENDED REMEDIES

Good weed control combined with planting the crop three weeks later is said to give maize good protection against the maize snout beetle.

Weed fallows can be used as trap crops and cowpea and velvet beans in rotation are said to control the insect.

Beetles: the larger beetles of this family can be best dealt with by Hand picking (A15) in the early morning, late evening or on cloudy days, by Hens etc. (A16), or by catching them at night in light traps: Various insects (C17 i). The smaller beetles are more troublesome and can appear in very large numbers. Their numbers can be depleted substantially by light traps: Various insects (C17 i). Hens etc (A16) are also useful for getting rid of those appearing during daylight hours. All sizes can be repelled by use of strong-smelling plants Aromatic (A1) or by the Biological (A4 i) method. Damage to the leaves can be reduced by dusting the leaves with lime (Clay etc A10 i) and those living in the soil can be trapped by dusting the soil surface around the plants: Ash (A ii), Clay etc. (A10 ii, iii).

The stronger Soap solutions (A25 ii) have been found useful against certain small beetles.

Insecticides recommended in the literature as effective against various beetles are: Garlic (B 1.2); Syringa (B 1.15); Oleander (B 1.16); African marigold (B 1.20); Goat weed (B 2.2); Mexican poppy (B 2.5); Blackjack (B 2.8); Wormseed (B 2.10); Lantana (B 2.15).

These would have to be sprayed or dusted (as per the recipe) on the plants at night or watered thoroughly into the soil during the day.

* Also worth trying are any of the insecticidal plants mentioned in B5 and particularly sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Routine spraying with mixtures of repellant plants from B6 may prove a useful preventive measure.

Eggs on the leaf: Ash (A2 i, ix, x, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Oil-mineral (A21 i); any of the insecticides listed in B6 particularly those * mentioned above controlling the adults.
Eggs in the soil: Ash (A2 ii); Hens etc. (A16) to dig the eggs from the soil; and strong sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26), should prove useful when watered thoroughly into the soil.
Pupae/larvae on leaves: Ash (A2 ix, x, xi); Clay etc. (A10 i, ii, v); Hens etc. (A16); any of the insecticides listed in B6 particularly those * mentioned previously for controlling the adults.

Pupae in the soil: Ash (A2 ii); Hens etc. (A16); Mulches (A19) aromatic; and again particularly those * mentioned previously for controlling the adults.

Pupae/larvae in the stems, bark or roots: dead or seriously damaged plant parts should be removed/dug up and destroyed. Old bark can be scraped off trees and builders' lime brushed on (A7 ii); or the exposed surface sprayed with either agricultural lime (A10 iv, v) or any of the insecticides listed in B6 particularly those * mentioned previously for controlling adults.

Checks

Ensure an adequate habitat for bird life that predate on the beetles and that there is a wide variety of insects to predate on the eggs and pupae.

CUTWORMS: (*NOCTUIDAE*)

Host plants

Cutworms attack young seedlings (mainly) of beans, brinjals, coffee, cotton, crucifers, cucurbits, groundnuts, maize, onion, peas, potatoes, soyabeans, tobacco, tomatoes and many other plants and crops.

CUTWORMS

Damage

This smooth, greyish caterpillar emerges from the soil at night, encircles the plant with its body and cuts through the stem of young plants just above ground level, leaving the wilting top to die. They will climb up mature plants and cut off lateral growth but usually do minimal harm at that stage of the plant's development. They are general feeders and will attack almost any kind of plant. A single caterpillar may cut down several seedlings in one night.

Life cycle

The dull-coloured moth emerges in spring and lays its eggs on the soil or on the foodplants. A single female may lay 600–800 eggs which hatch in approximately thirteen days into tiny black caterpillars. The young caterpillars initially feed on plant leaves for ten days before burrowing into the soil. Thereafter they live in the soil during the day, lying in a curled up position usually within 10–25mm of the surface, emerging only at night to feed. The fully grown 30mm long caterpillar burrows approximately 25mm and turns into a smooth reddish-brown pupa. It remains in the soil for 2–3 weeks before emerging as a moth. There may be up to four generations. Many insects predate on the cutworm at all stages in its life cycle. For example, a small parasitic wasp lays its eggs in the caterpillar and the wasp larvae gradually eat the cutworm.

Identification

The sight of the seedling top or severed laterals lying on the ground surface is often the first hint of the presence of the cutworm. A small hole may be found in the soil near the severed plant which, when excavated carefully, will reveal the curled up smooth greasy-grey caterpillar.

RECOMMENDED REMEDIES

A wide variety of simple but effective measures are available for controlling this pest.

Moths: Aromatic plants (A1); Biological (A4 i); Clay etc. (A10 x); Mulches (A19i,ii); Light traps (Various insects: C17); Repellant sprays (B6).

The bodies of the moths caught in the light traps: Various insects (C17) can be used as a Biological (A4 i) spray.

Liming acid soil is said to deter the moth from laying its eggs or to reduce egg fertility. Mulching also deters moths from laying eggs on the soil.

Eggs: Ash (A2 i, ii, ix, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Oil-mineral (A21 i); Pyrethrum (B 1.6); Tobacco (B 1.17); Rain tree (B 2.19); Cork bush (B 2.20); Tephrosia (B 2.26); Leadwood (B 4.9); African sandalwood (B 7.2). Make sure to spray or dust both the upper surface and underside of the leaves.

Caterpillars: Ash (A2 i, ii); Clay etc. (A10 iii); Hand picking (A15 iv); Hens etc. (A16); Manure etc (A17 i, iii); Mulch (A19 i, ii); Smoke etc (A24 i); Chilli (B 1.4); Pawpaw (B 1.5); Finger millet (B 1.8), Thorn apple (B 2.11); Castor oil (B 2.24); Sodom apple (B 4.16); Combretum imberbe (B 4.9); Spirostachys africana (B 7.2) and Cutworm (C8) have been specially identified in the literature as effective means for controlling the cutworm.

One of the simplest and most effective control measures is to concentrate hens or bantams (Hens A16) on to the beds before planting.

The squashed ripe fruit of Sodom apple steeped in water and dug into the soil is said to control cutworm.

Plants listed as Insecticidal (B5) are other possibles, particularly sprays made from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B. 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

The tin can and stick methods described in Cutworm etc. (C8 iii and iv) are effective emergency methods for small and medium size areas and very simple to apply. For larger areas, the best emergency approach is to water well into the soil insecticides made from the plants mentioned previously.

For small infestations dig the cutworm out the soil with a sharp stick. Carefully search around the base of the cut plant to find the small entrance hole to its hideout. Dig along the tunnel until the grub is found.

Another simple technique is to delay transplanting seedlings until the stems are too wide for the cutworm to encircle, too hard or woody for it to cut, or too strong-smelling to attract it.

Repeated disturbance of the soil surface is also said to reduce caterpillar numbers but, as this can have a detrimental effect on soil fertility, it should be a last resort.

Several sources recommend baits as alternatives. These can be made out of maize flour and water with plant poisons, pyrethrum and

rotenone (C8 ii) added in.

Another source has recommended watering around the plants with a mixture of one teaspoon of grated turnip having cooled after one litre of boiled water has been poured over it.

Checks

Check the pH of the soil; acidity is said to encourage the pest. Is there sufficient mulch? Ensure an adequate habitat for owls, nightjars, bats and other night creatures that predate on the moth; and for birds that will dig up the caterpillars during the day. Many other insects feed on the eggs and larva of this pest, so encourage as wide a range as possible of insect life both above and below ground. Plant diversity is not so vital as the caterpillars feed on almost all cultivated plants.

DIAMOND-BACK MOTH (*PLUTELLA XYLOSTELLA*).

Host plants

Cabbages, cauliflowers, other members of the cabbage family (crucifers) and some garden plants.

Damage

The small greenish caterpillars about 8mm long eat numerous small holes into the plant leaves which seriously affects the appearance and vigour of the plant. The leaves may be reduced to a network of veins in the case of severe infestations. It is active particularly in the dry season.

Life cycle

The ash-grey female moth lays her tiny yellowish-green eggs either singly or in small groups on the upper surface of the leaves. They hatch in a few days into small green caterpillars which move to the underside of the leaves to feed. They grow rapidly, attaining full growth in about 10–30 days, depending on temperature. The 12mm long caterpillars spin silk cocoons under the leaves in which they pupate. The adult moth emerges about one week later. There may be as many as ten generations a year and the female may lay 50 or more eggs. As a result their numbers can multiply very rapidly when conditions are favourable. Green and brown lacewings, parasitic wasps, spiders and larvae of hover flies are important predators of the caterpillars; while fungal diseases play their part in reducing the numbers of these pests during the rainy season.

DIAMOND-BACK MOTH

Identification

Numerous small holes in the plant leaves are usually the first signs of the pest. The small, green caterpillar can then be seen on the underside of the leaves, lying under a protective web. The caterpillar has the characteristic habit of wriggling actively when touched. The moth is a small grey insect. When the moth is resting, a pattern of three diamonds can be seen along the line where the wings meet over the back.

RECOMMENDED REMEDIES

Summer rains and frequent irrigations reduce the mating of the moths

and wash off young caterpillars and the pupae. Strongish sprays need to be directed on to the underside of the leaves to remove pupae.

Growing resistant cultivars, planting mustard as a decoy or trap crop and biological control through diseased specimens, have worked well.

Rotations effectively control moth numbers. Numbers of caterpillars have been reduced considerably by breaks of over 6 weeks during which no crucifers have been grown.

Dusting or spraying leaves with agricultural lime (Clay etc. A10) effectively controls eggs, caterpillars and pupae.

Supplementary measures

The following remedies have been specifically recommended in the literature for general control of the pest in all phases: Potassium permanganate (A22); Salt preparations (A23 ii); Garlic (B 1.2); Pyrethrum (B 1.6); Tomato (B 1.12); Feverfew (B 1.14); Syringa (B 1.15); Oleander (B 1.16); Tobacco (B 1.17); Sweet basil (B 1.18); Custard apple (B 2.4); Desert date (B 2.6); Catunaregam (B 2.9); Tephrosia (B 2.26).

Moths: Aromatic plants (A1); Biological (A4 i); Light traps (Various insects C17 i); Repellant sprays (B6).

The bodies of the moths caught in the light traps: Various insects (C17) can be used as a Biological (A4 i) spray.

Eggs: Ash (A2 i, ix, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Milk (A18 i); Oil-mineral (A21 i); Pyrethrum (B 1.6); Tobacco (B 1.17); Rain tree (B 2.19); Cork bush (B 2.20); Tephrosia (B 2.26). Make sure to spray particularly the upper surface of the leaves.

Treat crucifers routinely at regular intervals to prevent the eggs from hatching if unsightly holes in the leaves are to be avoided.

Caterpillars: Ash (A2 ix, x, xi); Biological (A4 i, ii); Clay etc. (A10 i, v); Glues (A13); Hens etc. (A16); Oil-mineral (A21 i-see warning); Potassium permanganate (A22); Salt preparations (A23 ii); Smoke etc. (A24 i); Soap solutions (A25 ii); Garlic (B 1.2); Syringa (B1.15); and Clausena (B 4.8) have been mentioned in the literature as possible controls for caterpillars. Plants listed as Insecticidal (B5) are other possibles.

Once the caterpillars have emerged, spraying immediately with Oil-mineral (A21 i), potassium permanganate (A22), or with sprays made out of Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26) should prevent the appearance of unsightly holes in the leaves.

If a few holes are not a problem, liberally dusting the caterpillars and their food with lime is likely to be the most convenient alternative but the lime should be washed off before the goods are marketed.

Pupae: Ash (A2 ix, x, xi); Clay etc. (A10 i, ii, v); Hens etc. (A16); and any of the insecticides listed in B6 particularly those already mentioned for rapidly controlling the caterpillars. Thoroughly spray the underside of the leaves to clear the pupae.

Checks
Ensure an adequate habitat for owls, nightjars, bats and other night creatures that predate on the moth; and for birds that will feed on the eggs, pupae and caterpillars during the day. Many other insects feed on the eggs and larva of this pest, so encourage as wide a range as possible of insect life. Pay adequate attention to rotations to break the continuity in the growing of crucifers. A break of 6–8 weeks in which no crucifers at all were grown in a market garden reduced pest numbers considerably.

FRUIT FLY: (*TEPHRITIDAE*)

Host plants
Apples, apricots, avocados, citrus, figs, grapes, guavas, mangoes, olives, pawpaws, peaches, pears, plums and quinces.

Damage
The maggots of the fruit fly eat into the flesh of the fruit and promote rotting.

Life cycle
In summer the female cuts a hole in the skin of the fruit and inserts a number of eggs. The eggs hatch in 2–4 days. The maggots feed on the tissues of the fruit for about 2 weeks. During this period the fruit is likely to rot and drop to the ground. At the end of this period the maggots are fully grown (10mm long) and leave the fruit to burrow into the soil and pupate. The adult flies emerge after 2–3 weeks. In winter the flies tend to congregate on the underside of leaves of certain trees like orange and loquat. The honeydew secreted by scale insects and aphids attracts them.

FRUIT FLY

The female fly also lays her eggs in the growing tips of the cabbage tree. The maggots then tunnel down the branches keeping just beneath the bark, causing a slimy mess under the bark and die-back of the shoot.

Identification
There are several species of fruit fly. This small fly can be recognised by its shiny eyes and striped wings. The body is light brown with darker markings: stripes or dots. It holds its wings at a wide angle to the body and appears to trail the back edge of them as it rests or walks. The maggots are small, legless and creamy white. The first signs of infestation are tiny brown punctures in the skin of the fruit from which clear gum exudes.

RECOMMENDED REMEDIES

The eggs and maggots, being buried in the fruit, are difficult to treat. The fly and pupa stages are the most vulnerable.
Fly: the following have been mentioned specifically as controls of the fly: Manure etc. (A17 ii); Finger millet (B 1.8); Flies (C9); Various insects (C17 iii).

Spraying with residues of finger millet soaked in water has been found effective against fruit fly.

Susceptible fruit should be picked early, when green if possible, to ripen in storage.

The flies can be repelled by spraying the fruit with the plant remedies listed in B6.

Timely and routine spraying of the fruit with the plant remedies listed in B5 will help to reduce numbers of flies and eggs. Those identified as treatments for flies in general may be worth trying first: Garlic (B 1.2); Chilli (B 1.4); Pyrethrum (B 1.6); Tomato (B 1.12); Feverfew (B 1.14); Oleander (B 1.16); Tobacco (B 1.17); Goat weed (B 2.2); Apple of Peru (B 2.21); Mexican marigold (B 2.25) and Woman's tongue (B 4.2).

A strong recommendation is to keep numbers of aphids and scale down to a minimum as fruit fly are attracted by the honeydew secreted by these insects. This can be done most economically by encouraging ladybirds and bird life into the orchard.

Maggots and Pupae: fallen fruit containing the maggots should be collected, buried deeply (50–100cm), composted or fed to livestock immediately. Grease bands have been recommended to prevent the larvae from crawling up and down the tree trunk. Hens etc. (A 16) will dig maggots out of the fruit and pupae from the soil. Hens etc. and orchards go well together. They can be assisted in their task by disturbing the soil under the fruit trees: Soil (A26 ii).

The Cabbage tree is a very useful trap crop for the pest. The infested branches should be cut off and destroyed as soon as the leaves begin to wilt under the maggot attack.

The pupae are said to pass the winter in loquats and particular care should be taken to remove the fallen fruit from under this tree.

Checks
For this pest particularly it is best to attack from as many possible angles at once. Hence spray, trap or repel flies, harvest early, collect and destroy fallen fruit and also get the hens to eat the pupae hiding in the soil under the trees. Are there enough Cabbage trees as decoys in the area? Are you encouraging bird life to come into the orchard with bird baths and so on?

GRASSHOPPERS: (*ACRIDIDAE*)

Host plants
Garden flowers, herbs, shrubs and vegetables.

Damage
The leaves and even the soft stems of young shoots will be eaten, impairing growth and destroying seedlings. They do the most damage to gardens in early summer before the surrounding bush can offer them sufficient green vegetation.

GRASSHOPPERS

Life cycle
The adults lay their eggs in the soil, just below the surface. In some species of grasshopper the eggs may lie in the ground all through

winter, hatching when the weather warms up. In this way the insects can survive prolonged dry periods during which food may be scarce.

Identification

Most grasshoppers can jump well and can fly strongly. Their hindwings are often brightly coloured. Their hindlegs are powerfully developed and many species have sharp spines on them. The 30mm long, brown, short-horned grasshopper is perhaps the most common grasshopper in gardens but locusts are included in the *Acrididae* family.

RECOMMENDED REMEDIES

Planting members of the Marigold (*Tagetes*) family as companion plants is said to give some protection against grasshopper attack.

Adults: the following remedies have been mentioned in the literature: Ash (A2 i, ii); Biological (A4 i, ii); Hand picking (A15 iii); Hens etc. (A16); Manure (A17 i); Mulch (A19 i); Tomato (B 1.12); Custard apple (B 2.4); Catunaregam (B 2.9); Leadwood (B 4.9); African sandalwood (B 7.2); Beetles etc. (C3); Various insects (C17 i).

Of these using hens, light traps (Various insects C17 i) and hand picking or, preferably, nets (C3) are simple and effective.

In addition some success in reducing adult numbers has been claimed by spraying and dusting with the stronger plant remedies like Pyrethrum (B 1.6), Tobacco (B 1.17), Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Eggs in the soil: since the grasshopper likes to lay its eggs in bare soil, ensuring dense living ground cover (crops and grassland) and Mulching (A19 i) will significantly reduce pest numbers. Hens etc. (A16) will help by digging up any eggs laid in patches of bare soil; and strong sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26), should prove useful when watered thoroughly into the ground.

Checks

Avoid destroying all blister beetles, their eggs and larvae as the larvae eat the eggs of grasshoppers. Check on the amount of vegetative cover in the garden and in the surrounding bush. Overgrazing and burning of the grassland, and particularly areas of ploughed but unplanted land, provide bare areas which are ideal breeding areas for the hoppers. Encourage an abundant bird life.

MAIZE STALK BORER

MAIZE STALK BORER: (*BUSSEOLA FUSCA*)

Host Plants

Maize, millet, sorghum and grasses.

Damage

The insect attacks members of the grass family. The leaves are perforated and the caterpillar bores into the stem causing loss of yield. The plant may dry up and die if the infestation is severe or the plant is weak.

Life cycle

The mature insect is a night-flying moth with a wingspan of about 35mm. The female moth lays her eggs in a cluster between the leaf sheaths and the stalk. The eggs hatch from 7–9 days after being laid. The young larvae make their way to the top of the plant and feed between the unopened leaves, perforating them. As they increase in size they become over-crowded. They then migrate to other maize plants and bore into the stems. A full-grown larva measures about 30mm. It pupates within the stem. The adult moth emerges after 2–3 weeks. Maize grown under the natural rainfall is attacked by 2 main broods of the moth. The first brood emerges shortly after the first rains in November/December, and causes a lot of damage. The second brood appears in February/March, tends to attack the tassels and grain but the damage is much less severe. This brood passes the winter as a larva within the maize plants and gives rise to the spring brood of moths. Many insects predate on the moth, egg, caterpillar and larval stages of this pest including ants, ladybirds, parasitic wasps, spiders, birds and many others.

Identification

The moth can be seen hovering around the maize plants on moonlit nights. Its forewings are reddish brown and the hindwings yellowish brown. The eggs can be seen clustered between the leaf sheath of the plant and the stalk. The grubs are dark coloured at first and can be seen by splitting the sheath downwards until they are exposed. Blobs of rotting vegetation are excreted by the grub. Later the grubs become pale in colour and exit holes can be seen in the lower stem.

RECOMMENDED REMEDIES

Stalk or stem borers can be effectively controlled by composting all infected plant residues or feeding them to the cattle. The compost/manure can then be returned to the field.

The pest's life cycle can also be broken by practising rotations, with wide gaps between members of the grass family.

Intercropping, mixed cropping, strip cropping and Permaculture designs reduce moth attack because the moth apparently recognises the host plant by its silhouette (outline). Thus tall intercrops such as tomato, sunflower, climbing beans, and so on, give better protection than short intercrops.

Another tactic which is said to reduce the incidence of attack in a field is to plant a susceptible maize hybrid, with the first rains, around the edges of the field to act as a trap crop, which is then cut for fodder. These methods, however, are far less satisfactory than composting or rotational practices mentioned previously.

Maize grown for silage which is planted at the start of the rains can act as a decoy or trap crop. The caterpillars or larvae are then killed off when the maize is turned into silage. Similarly, silage maize can be planted in mid-January to divert the second brood from the grain crop.

As the moths are most active during the full moon and are attracted to plants 3–4 weeks old, the best time to plant is between two full moons. It is also possible to plant at a higher density than optimal and chop out the infected plants later for fodder. Full moon is also the best time to catch the moths in light traps as there are more of them about at that time.

Other recommended planting strategies are either to plant 3–4 weeks after the start of the rains when moth activity has lessened or to plant 1 month before the start of the rains using irrigation.

One farmer reports that he controls stalk borer in sorghum by cutting off and destroying the central shoot of the plant (containing the stalk borer) before the plant flowers. Lateral shoots grow to replace the main one.

Moths: Aromatic plants (A1); Biological (A4 i); Gum tree (B 1.9); Light traps: Various insects (C17); Repellant sprays (B6).

The bodies of the moths caught in the light traps: Various insects (C17) can be used as a Biological (A4 i) spray.

One farmer reports that spraying plants (especially the tops and bottoms) with powdered gum tree leaves proved an effective repellant to the moth particularly when the days were sunny.

Eggs: Ash (A2 i, ix, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Manure etc. (A17 ix); Oil–mineral (A21 i); Pyrethrum (B 1.6); Tobacco (B 1.17); Rain tree (B 2.19); Cork bush (B 2.20); Tephrosia (B 2.26). Make sure to spray particularly around the leaf sheaths.

Caterpillars: Various preparations can be poured down the funnel of maize plants when they are about knee high or when first signs of leaf damage occur. Ash (A2 i) and Soil (A26 i) are mentioned particularly in the literature; Tephrosia (B 2.26) gave effective kills in a field trial: Tobacco (B 1.17) performed well but recommended concentrations should not be exceeded if plant damage is to be avoided; Thorn apple (B 2.11), Lantana (B 2.15) and Red sunflower (B 4.18) were only partially effective. Others which have shown promise are Pyrethrum (B 1.6), Rain tree (B 2.19) and the Cork bush (B 2.20).

The above liquid preparations can also be sprayed on the leaves to kill eggs and the newly-hatched caterpillars.

These preparations are most effective when the stalk borer caterpillar is small and resting either on the leaf or in the leaf sheath before boring into the stem.

The crop should be treated at least twice and preferably three times at 7-day intervals once the infestation is evident.

Pupae: pupae can best be destroyed by composting the crop residues or feeding them to livestock. Alternatively, when the residues are to be retained as mulch the method given in Sun (A29 i) should be followed.

By far the simplest method of controlling maize stalk borer are rotations and removing all the residue from the land and turning it into compost or feeding it to the cattle. For the small number of plants still attacked, pouring soil into the funnel gives very effective control at no cost and little effort.

Checks

Ensure that the residues of all host plants (sorghum, maize and millets) are free of borer larvae or are turned into manure or compost. Encourage surrounding growers to follow similar practices. And, of course, do everything possible to reinstate a wide variety of bird and insect life. Ants are fond of the pupae and will find them by going down the borers tunnels in the maize stem.

NEMATODES: (*NEMATODA*)

Host Plants

Apples, avocados, citrus, figs, garden flowers, grapes, pawpaws, peaches, pears, strawberries, vegetables — particularly: bambara nut, beetroot, brinjals, beans, carrots, celery, cowpeas, cucumbers, cucurbits, gourds, potatoes, leeks, lettuce, melons, okra, onions, parsley, peas, pumpkin, sorghum, squash, sugar bean, sweet pepper, swiss chard, tomatoes, tsenza; and cotton, millets, sunflowers, tobacco.

Damage

Nematodes attack a very wide range of plants causing poor growth, wilting, poor development of leaves and fruit, yellowing of leaves and other nutrient deficiency symptoms, with potentially dramatic loss of yield. The ends of branches can die in tree crops. Nematodes which leave open wounds in the root tissue encourage the occurrence of plant diseases. However, the majority of nematodes are essential to good soil structure as they break down organic matter into humus.

Life cycle

Nematodes live mainly in the soil. They are worm-like creatures which feed on soil bacteria, fungi, algae, other nematodes and some feed on the roots of plants. Root-knot nematodes are microscopically small. The young root-knot nematode burrows into the root tissue of the plant where it matures and lays eggs, causing localised swellings on the roots. The young emerge from the eggs and move into the soil in search of another suitable plant. The life cycle from egg to adult is about 4 weeks and the juvenile nematode can survive for a couple of years without finding a suitable plant host. Other nematodes do not live in the roots but live in the soil, lay their eggs there and feed on the roots without entering them. Some nematodes are beneficial organisms as they keep each other in check and parasitise the larvae of many insects including armyworm, beetles, bollworm and leaf miner.

Identification

Most plant-parasitic nematodes cannot be seen with the naked eye. The presence of these parasites must therefore be identified from the damage to the plant and its roots. Apart from the above-ground evidence of damage as described, which is common to all nematode attack, the cause should be confirmed by examination of the plant roots. The root-knot nematode causes localised swellings on the roots, lesion and ring nematodes cause dead spots to appear around their feeding points and

nematode root knot damage

NEMATODES

dagger nematodes cause swelling and distortion of the roots on plants.

RECOMMENDED REMEDIES

Nematodes are always in the soil but in balanced, harmless numbers. Numbers of root-knot and other crop-damaging nematodes increase dramatically as soon as the soil is ploughed and/or organic matter decreases. The continuous growing of host crops adds to the problem by ensuring adequate food supplies for the inflated nematode population.

The most permanent solution is therefore to minimise soil disturbance, to ensure as high a level of soil organic matter as possible and to include nematicidal plants in the rotation.

Raising soil organic matter: soil organic matter can be raised by no or minimal digging, by mulching, and by including crops in the rotation which add much organic matter to the soil through their dense root networks (preferably) and/or prolific above-ground vegetation which can be used as residue. For example: millets, maize, many types of beans both bush and creeping, sunnhemp, lucerne, silver leaf and other fodder grasses; also direct additions of Compost (A12 ii), Manure etc. (A17 viii) and Mulch (A19 i) to the soil surface.

Sunnhemp has the potential to not only improve soil organic matter but also to act as a trap crop for nematodes by preventing the female from maturing.

Plants with nematicidal properties: garlic, cassava, leeks, mustard, onions, shallots, pawpaw, African and French marigold, Mexican poppy, Mexican marigold and spear grass.

Rotations: apart from the nematicidal plants already mentioned which can also be introduced into rotations, several grasses are known to be non-hosts or very poor hosts to root-knot nematode. These are *Eragrostis curvula* (Weeping Love grass), *Chloris gayana* (Katambora Rhodes grass), *Panicum coloratum* (Bambatsi Panicum), *Cynodon dactylon* (Couch), *Paspalum notatum* (Paraguay grass) and *Panicum maximum* (Sabi Panicum). When grown in extended rotation (several years of grass included) nematode numbers are decreased significantly.

Among the crops said to be poor hosts or resistant to nematodes are garlic, leek, onion, early planted green maize and sweet corn, and shallots. Those said to be able to tolerate attack are: broccoli, brussels sprouts, cabbage, cauliflower, kale, rape, radish, leaf mustard, turnip, sweet potato and chillies.

In addition, it is said that traditional vegetables are usually tolerant or even resistant to indigenous pests and diseases including root-knot nematodes, and could be included in the rotation to advantage; whereas the ones of European origin are more susceptible.

Cropping strategies recommended by experts are:

— Plant susceptible intercrops such as pumpkin, okra, cowpea and bambara nut into a field of maize, sorghum or millet.
— Grow winter (irrigated) crops of European-type vegetables in strict rotation with crucifers or alliums. Grow green maize on this same land during the early summer to reduce the nematode population.
— Sterilise seed-beds by burning wood or other materials on the soil and change/rotate the position of the seedbed, selecting previously uncultivated ground wherever possible.
— Flood seedbeds and plots with standing water for a minimum of 4 weeks prior to planting.
— Plant known resistant plants or varieties and nematode-free roots, tubers, seedlings and cuttings.
— Plant susceptible crops in winter during periods when the soil temperatures are below 15°C as the nematodes are relatively inactive at lower soil temperatures.
— Remove infested roots immediately after harvest, dry and burn them. The tops can be composted but don't use the infected roots as nematodes can survive in the cooler parts of the heap.
— Add copious amounts of organic matter to the soil like compost, mulches, legumes (particularly sunnhemp), manures and through the root systems of uninfected plants left to decompose in situ. High levels of organic matter which encourages a healthy plant and a good pest/predator balance will control nematode numbers.

Others: Citrus trees are said to be protected from nematode attack by planting legumes underneath (like cowpea) or nearby (acacia trees).

Emergency tactics

Other methods specifically recommended in the literature are: Ash (A2 iv, vii); Burning (A9); Sugar (A27); Garlic (B 1.2); Pawpaw (B 1.5); Tomato (B 1.12); Cassava (B 1.13); Syringa (B 1.15); Goat weed (B 2.2); Sugar apple (B 2.3); Mexican poppy (B 2.5); Thorn apple (B 2.11); Castor oil (B 2.24); Chinese lantern (B 4.10); Spear grass (B 4.12).

Sugar is particularly useful for destroying root-knot nematodes in seed potatoes before planting by soaking them in sugar water and then rinsing. It may be a practical method for potting and small garden plots but not for large areas.

Checks

Check that soil disturbance is minimal; that existing soil humus levels are high; that there is an adequate programme to maintain organic matter levels; and that nematicidal or resistant crops and soil-improving plants are part of the rotation.

RED SPIDER MITE: (*TETRANYCHUS SPP.*)

Host plants

Apples, apricots, beans, brinjals, carnations, carrots, citrus, cotton, crucifers, cucurbits, deciduous fruits, grapes, nectarines, peaches, pears, plums, potatoes, roses, soyabeans, strawberries, sweet potato, taro, tobacco, tomatoes, and others.

RED SPIDER MITE

Damage

There are several kinds of mites of different colour but the red spider mite is probably the most widespread. These insects suck the sap from plants causing retarded growth, leaf-fall or death.

Feeding initially causes yellow spots to form on the leaves which gradually spread until the whole leaf is yellow and drops prematurely. They do not like wet conditions and outbreaks tend to occur in warm, dry conditions.

Life cycle

The female lays her eggs on the underside of plant leaves protected by the fine web spun by the insect. She lays about 15 eggs a day for about 3 weeks. In hot weather it takes only 10 days from egg to adult. This rate of reproduction can result in a very rapid build-up in numbers. It is said that they can remain dormant in the soil or on plant residues for a long time before colonising plants. Ants, lacewing larvae, ladybirds, praying mantis and other mites predate on the red spider mite.

Identification

The red spider mite is a small oval insect 0.5–0.7mm in length. It has four pairs of legs and is reddish brown in colour. The first sign of infestation often is the presence of yellow spots on the upper surface of the leaves. In heavy infestations they can be clearly seen massing on the underside of the leaves of the host plant, the crop having a reddish colour. They spin silken webs over themselves, hence the name red spider mite.

RECOMMENDED REMEDIES

Rotations are particularly important in the control of this insect. The situation is currently particularly serious on lands planted to cotton, crucifers and tomatoes without due attention to rotating with non-host crops. Overuse of modern agricultural chemicals has built up a large resistant population while effectively removing most of the predators of the red spider mite. These predators such as ladybirds/bugs, mantises, lacewings and ants should be allowed to build up to re-instate the natural pest/predator balance.

Maintaining the humidity in the crop as high as possible (A4 iii) will repress numbers of spider mite as they do not like damp conditions. This can be achieved by close plant spacings, mulching, spraying the plant leaves with a water jet and frequent irrigations.

Increasing the plant diversity will also improve protection. A hedge of perennial pigeon pea around the field is recommended as a breeding site for other mites which predate on the red spider mite, and increased humidity in the garden will further reduce pest numbers.

Interplanting with garlic, basil, onions and other aromatic plants is said to give some protection.

Supplementary measures

The following measures are said to control the insect at all stages in the

life cycle: Ash (A2 i, ix, xi); Biological (A4 iii); Clay etc. (A10 i, ii, iv, v, vi); Glues (A13); Hand picking (A15 ii); Manure etc. (A17 iii), Milk (A18 i); Oil-Mineral (A21 i)— see warning; Potassium permanganate (A22); Soap solutions (A25 i, ii, iii); Sulphur (A28); Water (A31 i); Onion (B 1.1); Garlic (B 1.2); Pyrethrum (B 1.6); Tomato (B 1.12); Syringa (B 1.15); Tobacco (B 1.17); Sweet basil (B 1.18); Blackjack (B 2.8); Euphorbia (B 2.13); Rain tree (B 2.19); Cork bush (B 2.20); Wild basil (B 2.23); Castor oil (B 2.24); Plant Mixtures (B 3.3, 3.6).

In addition, any of the Insecticidal plants (B5) should be tested.

The effectiveness of repellants on red spider mite (B6) is as yet unknown; but the ones mentioned as useful in interplanting: basil, chives, garlic and onions, should be appropriate.

Checks

Ensure plant diversity is sufficient through practising rotations, mixed, inter, strip and trap cropping and Permaculture designs. Consider using cultivars known to be resistant to red spider mite. Check that spraying is done as infrequently as possible and spot spray to avoid killing off predators.

SCALE INSECTS: (*COCCIDAE*)

Host Plants

Apples, apricots, avocados, citrus, coffee, deciduous fruits, figs, granadillas, grapes, mangoes, mulberries, olives, peaches, pears, plums, quinces; protea, roses, sisal and many other orchard trees and garden plants.

Damage

Scale insects suck the sap of plants and may have a toxic effect causing loss of health or death of the plant. They are mostly a pest of orchard trees and other woody plants. Palms, ferns, herbaceous plants and sisal are also attacked.

Life cycle

Armoured scales protect themselves by secreting a waxy shield which grows in size as the insect matures. The waxy substance is further protected by a hard surface made up of their own moulted skins. The male eventually emerges from the shield and flies off. The females remain under the waxy cover and produce their young beneath it, usually as eggs (a few species produce young directly). The young larvae hatch, emerge and enjoy a brief, active period during which they seek new places to settle. They then moult, becoming adults, then secrete the waxy protection. Soft scales do not have a hard cover, the soft coating being made of solidified watery wax. Naked scale varieties do not secrete wax but are protected by their own horny backs. The natural controls for these insects are birds, parasitic wasps and larvae. Beetles of the Coleoptera family have been reported eating scale insects.

wax scale — acacias

SCALE INSECTS

Identification

Armoured scale insects commonly seen grouped on the leaves of mango trees are small, white and elongated. Blemishes on the leaf caused by toxic reaction can clearly be seen. The adults of the species look like small, white, grey or reddish-brown shells glued to the branches or leaves of the plant. Lines of ants can be seen on their way to collect the honeydew secreted by soft scales. Armoured scales do not secrete honeydew.

RECOMMENDED REMEDIES

The incidence of scale can be reduced by pruning heavily infested branches in winter. Controlling the ant population which feeds off the honeydew secreted by soft scales will allow predators to do their job — see *Ants*.

The following are specifically recommended in the literature: Ash (A2 ix, xi); Baking soda (A3); Clay etc. (A10 ii); Oil (A21 i, ii, iii)— see warning; Soap solutions (A25 ii); Sulphur (A28); Onion (B 1.1); Tobacco (B 1.17); Catunoregam (B 2.9).

In addition, any of the Plant Mixtures (B3) and Insecticidal plants (B5) should be tested.

The effectiveness of Repellants (B6) is as yet unknown.

For scale on woody branches or plants with naturally oily leaves (mango, sisal), brushing or spraying with vegetable or mineral oils is very effective. Water-mixable mineral oils will give equally good results on vegetation with non-oily leaves.

Checks

Scale is normally kept in check by bird life, parasitic enemies and by ensuring healthy plant growth. Therefore when plants are infested with scale, pay particular attention to those factors ensuring healthy plant growth: soil fertility, watering and seedling vigour. Provide a suitable habitat for birds: fruit trees, shrubs and permanently-filled bird baths.

SLUGS AND SNAILS: (*PHYLUM MOLLUSCA*)

Host plants

Almost any plant except some of the aromatic bitter ones.

SLUGS AND SNAILS

Damage

These small animals eat the leaves off plants, produce unsightly holes in fruit and can completely destroy seedlings leaving only a short stem protruding from the earth.

Life cycle

Slugs and snails favour damp places. Their round, white eggs are laid in the soil, under leaves or under any object in contact with the soil.

Identification

Slugs and snails are soft-bodied animals, snails with shells and slugs without. They grow up to about 7–8cm long and leave slimy, silvery trails behind them, which are detectable for days afterwards. Large snails with conch-shaped shells can be found sometimes. They are said to prey on their smaller cousins.

RECOMMENDED REMEDIES

Remedies in the literature recommended for controlling both slugs and snails are: Ash (A2 ii); Builder's lime (A7 i); Clay etc. (A10 iii); Coffee etc. (A11 i); Hand picking (A15 iv); Hens etc. (A16); Mulch (A19 i, ii); Salt (A23 iii); Smoke etc. (A24 i); Soap solutions (A25 ii) with paraffin added: Tea (B 1.3); Chilli (B 1.4); Finger millet (B 1.8); Tobacco (B 1.17); Desert date (B 2.6); Barbados nut (B 2.14); Wild tobacco (B 2.22); Slugs and snails (C14).

Those mentioned for slugs only are: Biological (A4 i), Clay etc. (A10 i) and under Caterpillars etc. (C7). Spinach planted in lines is said to repel slugs.

Slugs and snails can survive only in permanently wet conditions. Their numbers can be controlled by allowing infested areas to dry out thoroughly over winter.

Dusting around the plants with finely ground-up tobacco leaf scrap or agricultural lime are very effective methods but need repeating often. Too much lime will make the soil too alkaline.

Dusting floors with builder's lime (avoid the plants) is an efficient way of removing slugs and snails from nurseries but having the legs of nursery tables sitting in tins full of water does the trick too.

Hand picking is slow, labour-intensive and needs repeating often; wet days are the best time. Similar problems are experienced with traps. These methods reduce adult numbers but do not get to the root of the problem. New generations keep emerging.

Allowing free range to bantams is thoroughly recommended as these useful creatures prefer insects for food and do little damage to plants. On the other hand, hens and ducks love greens and should be fenced into the orchards where they can do no damage and moved on to the garden to clean up unplanted areas between crops in the rotation.

A useful tactic is to delay planting out seedlings until they are large enough and the growth sufficiently vigorous to withstand attack.

Checks

Keep the ground clear of non-essential materials lying on the soil which provide perfect hiding places for slugs and snails and their eggs: boards, bricks, sacks, tins, pots, stones and so on, unless they have been deliberately placed there as traps. Small animals such as toads, moles, mice, hedgehogs and large predatory snails, as well as many insects are said to feed off both the adults and the eggs.

Birds are essential to control numbers of these troublesome pests.

STINK OR SHIELD BUGS — ANTESTIA (*ANTESTIOPSIS SPP.*), BAGRADA. (*BAGRADA HILARIS*) AND GREEN STINKBUG (*NEZARA VIRIDULA*)

Host plants

A wide variety of plants are attacked. Antestia bugs attack coffee and orchard trees and protea. Bagrada bugs prefer pawpaws, crucifers and garden flowers, while their nymphs attack a wide range of food plants. Green stinkbugs are known to be able to feed on about 200 different plants including grapes, millets, soyabeans and tobacco.

Damage

The bugs suck the sap from the plants causing wilting and death of the leaves, growing tips or, in the case of heavy infestations, the whole plant may die.

adult bagrada bug

STINK OR SHIELD BUGS

Life cycle

The life cycle of the antestia bug will serve as an example. The female lays her eggs on the twigs and leaves of the chosen food plant in clusters of 10–14. She lays several batches and then dies. The eggs are about 1.5mm long, pearly white and shaped like short, stout barrels with lids on the top through which the young appear. The eggs darken and hatch in 10–14 days into nymphs which are black and wingless but look similar to the adult bug. They scatter and feed on sap for the next 12 days, then rest and moult. Their colour changes to bright yellow and black spots. As they continue to feed they shed their skin another 4 times whereupon the adult stage is reached. The whole life cycle from egg to death of the adult takes about 100 days, giving three generations per year. The eggs are parasitised by a tiny black wasp. The green stinkbug cycle is identical to the antestia bug but the female bagrada bug lays its small, barrel-shaped, greenish-white (at first) to pink mottled (later) eggs in the soil near to the host plant or on the leaves. They hatch in about 5–7 days. The subsequent stages, however, are the same as for the other two bugs.

Identification

There are well over 4,000 known species of shield or stink bug. Their bodies are flattened and shield-shaped. If roughly handled they give off a strong, unpleasant odour. They do not have biting jaws like beetles but a slender tubular probe which is carried folded back against the underside of their bodies. The Antestia bug is about 10mm, usually yellowish-green in colour with orange and black markings but can be green with red, yellow and blue markings. Bagrada bugs are often seen in pairs. They are about 6mm long, black, with a few bright yellow or orange markings, the nymphs being bright red. The so-called green stinkbugs can be green or brownish-green and are about 15mm long.

RECOMMENDED REMEDIES

Large beetles: the larger types of beetles, not usually appearing in great numbers together, are best treated by simple methods: Aromatic (A1) to repel them; Biological (A4 i); Hand picking (A15 i); Hens etc. (A16); Beetles (C3).

Small Beetles: Aromatic (A1); Ash (A2 ix, xi); Biological (A4 i); Clay etc. (A10 i, ii, ix) — particularly lime; Hens etc. (A16); Manure (A17 i); Soap solutions (A25 ii); Tea (B 1.3); Pawpaw (B 1.5); Syringa (B 1.15); Mexican poppy (B 2.5); Lantana (B 2.15); God's tobacco (B 2.18), Castor oil (B 2.24); and the Tung tree (B 4.3) have been specifically identified in the literature.

A solution of green bar soap in water has been found effective against Bagrada bugs.

Insecticides recommended in the literature as effective against various beetles are: Garlic (B 1.2); Syringa (B 1.15); Oleander (B 1.16); African marigold (B 1.20); Goat weed (B 2.2); Mexican poppy (B 2.5); Blackjack (B 2.8); Wormseed (B 2.10).

* Also worth trying are any of the insecticidal plants mentioned in B5 particularly sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Routine spraying with mixtures of repellant plants from B6 may prove a useful preventive measure.

Trials with different coloured containers as traps (C4) and light traps: Various insects (C17 i) may yield useful results.

Nymphs on leaves: Ash (A2 i, ix, x, xi); Clay etc. (A10 i, ii, v); Hens etc. (A16); any of the insecticides listed in B6 particularly those * mentioned previously for controlling the adults.

Eggs on the leaf: Ash (A2 ix, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Oil-mineral (A21 i); any insecticides listed in B6 particularly those * mentioned previously for controlling the adults.

Eggs in the soil: Ash (A2 ii); Hens etc. (A16); and strong sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26), should prove useful when watered thoroughly into the soil.

Checks

Ensure an adequate habitat for bird life that predates on the beetles and that there is a wide variety of insects to predate on the eggs and nymphs. Tree, hedge and plant barriers will often prevent the beetles from flying into the field. For the same reason intercropped or mixed cropped plants suffer less.

TERMITES: (*TERMITIDAE*)

Host plants

Fungus-growing termites feed on dead grasses, young woody plants, the old bark off mature trees and any dead organic material. They will consume live plant material when no other food is available, particularly groundnuts, maize and millets. Harvester termites will collect green material stripping the veld of grass and the leaves from shrubs.

TERMITES

Damage

Hundreds of species of termites exist in Africa alone, of which a few are considered important because they damage plants. Of these few, the fungus-growing termites are probably the most troublesome. Fungus-growing termites are known to attack the roots of young shrubs and trees during the first two years after they have been planted, causing retarded growth or death. They do no harm, however, when feeding on the dead bark of established trees. These termites are also known to attack field crops in semi-arid regions but usually only do so when plants are already weak (for example, wilting) or when no other food is available to them (for example, no other sources of organic matter such as mulch and soil humus).

Life cycle

Most termites that damage crops and trees live in nest systems constructed well below ground. The fungus-growing termites, which cause the most damage to trees and crops, live on wood and other plant material (usually dead). The collected plant material is taken back to the nest for the construction of fungus gardens, which are visculated with a special species of fungus (*Termitomyces*). This fungus breaks down the plant cellulose and enables the termites to use the plant material as food. The queen and king live in a thick-walled, mud cell in the centre of the termitary, usually a high mound or vertical shaft. Workers carry away the eggs as she lays them. The queen and king never move away from the cell; but each year during the rainy season winged termites (potential kings and queens) appear in the colony and fly off. They then pair off and form new colonies. Termite numbers are controlled particularly by ants, birds, reptiles, amphibians and mammals.

Identification

The presence of the fungus-growing termites can be detected from the mud tunnels they build en route to and around the material to be attacked. The fungus-growing termites are about 10mm long, white-bodied with brown heads and the soldiers have prominent pincers.

RECOMMENDED REMEDIES

Soil disturbance upsets the pest/predator balance among termites and favours those which are more likely to attack plants.

Termite attack on crops has been observed to be related to the loss of organic matter in the soil. Therefore all means should be taken to improve soil organic matter content.

Generally termites will attack only weakened plants under stress, particularly those under moisture stress thus moisture conservation techniques (conservation-tillage), which reduce surface run-off, should be applied at all times and the encouragement of healthy plants through compost and manure additions.

When there is no other food available to them as is often the case on arable land, termites have no option but to attack green plants. If mulch, dead grass, compost, manure or litter is present they will feed off that in preference to green material. So avoid having bare, dry, disturbed, residue-free soil around the plants.

Damage to crops can be lessened by harvesting the crop as soon as possible and drying it off the land.

Certain trees are resistant to termite attack: Acacia sp, Cassia sp, Colophospermum mopane, Markhamia sp, Meliaceae sp (Mahogany family), Pterocarpus angolensis and Terminalia spp.

Other strategies to protect young trees are: avoid seedling containers made of materials attractive to the termites like bark, paper or cardboard, take only the base of the plastic bag off the seedling plant and leave the top of the bag jutting above ground level and plant just after a heavy storm when the soil is moist.

Supplementary measures

Supplementary measures specifically recommended in the literature are: Ash (A2 v, vi); Biological (A4 i); Mulch (A19 i); Smoke etc. (A24 iii); Water (A31 i); Garlic (B 1.2); Tea (B 1.3); Pawpaw (B 1.5); Syringa (B 1.15); Tobacco (B 1.17); Sweet basil (B 1.18); American aloe (B 2.1); Mexican poppy (B 2.5); Blackjack (B 2.8); Catunaregam (B 2.9); Wormseed (B 2.10); Rubber hedge (B 2.13); Lippia (B 2.17); Wild basil (B 2.23); Castor oil (B 2.24); Mexican marigold (B 2.25); Albizia anthelmintica (B 4.1); Swallow wort (B 4.6); Finger grass (B 4.11); Red mahogany (B 4.13); Sodom apple (B 1.16).

Liquid from blackjack seeds and tobacco leaves has been found very effective locally as has the use of smoke and lemon-flavoured herbs such as lemon grass, vetiver grass and penny royal.

The leaves of Aloe graminicola crushed and the leaves or berries of Oximum applied to planting holes or watered into the soil around plants are said to protect plants from termite attack. In addition the leaves of Cassia siamea can be used as a protective mulch; and extracts from the leaves of Commifora africana (Corkwood) and from the roots of Adenia gummifera (Monkey rope) are said to have potential in termite control.

Castor oil cake soaked for 2 weeks in the latex from aloes can give eight months' protection to trees which have had the mixture painted around the base of their trunks.

Diesel, paraffin and used engine oil have also proved effective in repelling termites from their termitaries and from houses and earth dams; and have been painted onto the trunks of trees or mixed with the soil at planting time to protect them against termite attack. These products should not be used in the garden as they are harmful to plant and soil life.

Checks

Make sure that the soil is being disturbed as little as possible, that there is plenty of humus in the soil and dead material to feed the termites, and that the soil is kept as moist as possible. In short, avoid having bare, dry, disturbed, organic-deficient, residue-free soil. Allow time for the pest/predator balance to be restored.

THRIPS: (*THYSANOPTERA*)

Host plants

Apples, avocados, beans, brinjals, citrus, crucifers, cucurbits, garlic, grapes, green peppers, guavas, mangoes, onions, peas, tomatoes and many garden plants.

Damage

Due to their feeding activities these very small sap-sucking insects cause scars and blemishes on leaves, fruit and pods of a wide range of plants. Onion thrips attacks many vegetables and may cause plants to wilt and die. Onion thrips is a vector of tomato spotted wilt virus.

Life cycle

The adults are very small (1–3mm long), yellowish, slender insects having four oar-like wings fringed with long hairs. They breed throughout the year although they favour warm, dry weather. The female lays her eggs in the leaf tissue and they hatch in about 4 days. In warm weather the cycle from egg to adult is about 16 days. The insect tends to hide in the leaf sheaths or under the leaves. Some species pupate in the soil.

THRIPS

Identification

Few of these insects exceed 2mm in length and nearly all of the 5,000 or more species are black, brown or yellow. Signs of damage to plants is usually the first evidence of their presence, although a keen observer might detect a deposit of tiny black specks on the plant leaves. Arising from feeding, the insects leave white or silvery patches and streaks on leaves, fruit and pods. Citrus thrips causes grey or brown blemishes around the stem and navel ends of ripe fruit. Heavy infestation on beans causes a roughened silvery texture on the pod. Onion thrips gives a silvery appearance to the leaves of many vegetables. The leaves of grapes become silvery and the fruit may be scarred brownish red.

RECOMMENDED REMEDIES

Remedies specifically recommended in the literature are: Ash (A2 ix, xi); Clay etc. (A10 i, iv, v); Glues (A13); Hens etc. (A16); Manure etc. (A17 iii); Mulch (A19 i, ii); Oil (A21 i) — see warning; Soap solutions (A25 i, ii, iii); Water (A31 i); Onion (B 1.1); Tobacco (B 1.17) — see warning; and Various insects (C17 iii).

Potassium permanganate (A22) should be worth trying and, in addition, any of the Plant Mixtures (B3) and Insecticidal plants (B5) should be tested, particularly strong sprays from Pyrethrum (B 1.6), Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Spray plants in blossom in the evening to avoid killing off bees and other useful insects.

The effectiveness of Oils (A21) should be investigated, particularly light, water-mixable mineral oils.

Adult thrips can be trapped by hanging blue or yellow sticky boards

in the nursery or garden. A light coating of clean engine oil can be used in place of glues.

Hens can clear pupa from the soil or the soil can be sprayed with rotenone products and liquid tobacco or dusted with dried tobacco.

Any of the measures mentioned for aphid and whitefly also have the potential to control thrips, though thrips are more difficult to treat because of their tendency to hide in buds and leaf sheaths and to lay their eggs in slits in the plant leaves. Spraying with lime/sulphur mixes, however, has been recommended.

The effectiveness of repellants (B6) is as yet unknown but routine spraying with repellants may have potential.

Checks

Since thrips feed on aphids and on their own kind they should not be eradicated entirely but a certain level of damage accepted as necessary to maintain the pest/predator balance. As is the case with all insects, going to the extreme of trying to kill off all members of a particular species often recoils in the form of an outbreak of other insects. Some species favour particular plants, and rotations should be a useful way of containing the problem.

TIP OR TWIG WILTERS: (*ANOPLOCNEMIS CURVIPES*)

Host plants

Beans, brinjals, cucurbits, granadillas, guavas, mangoes and many garden plants. Tip wilters are a major pest of cowpeas in Africa.

Damage

These bugs suck sap from stems, leaves, pods, buds and growing tips of a wide variety of plants causing them to wilt and die back.

Life cycle

Over 200 species of tip wilter have been recorded. The eggs are cylindrical and barrel-shaped, deposited in rows of about 15 on the stems of young or healthy plants. They hatch in about 14 days and, like shield bugs, the nymphs moult 5 times in the process of becoming adults. Two to four generations can be produced per year.

TIP OR TWIG WILTERS

Identification

The adults are usually large, 25mm long, angular, usually pale grey to dark brown, elongated bugs which exude an unpleasant odour when handled roughly. They are winged and, in most species, the hind legs of the male are enlarged.

RECOMMENDED REMEDIES

Adults: remedies specifically recommended in the literature are: Biological (A4 i); Clay etc. (A10 ii); Hand picking (A15 i).

These large beetles can often be caught in nets: Beetles etc. (C3) and use of coloured traps: Beetles (C4) and light traps: Various insects (C17) may prove useful.

* Also worth trying are any of the insecticidal plants mentioned in B5 - particularly sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), Lantana (B 2.15), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Nothing appears to be known concerning the effectiveness of Repellants (B6).

Eggs on the leaf: Ash (A2 i, ix, x, xi); Clay etc. (A10 i, v); Hand picking (A15 ii); Oil-mineral (A21 i); any of the insecticides listed in B6 particularly those * mentioned previously for controlling the adults.

Nymphs on leaves: Ash (A2 ix, xi); Clay etc. (A10 i, ii, v); Hens etc. (A16); any of the insecticides listed in B6 particularly those * mentioned previously for controlling the adults.

Checks

Ensure an adequate habitat for bird life that predate on the beetles and that there is a wide variety of insects to predate on the eggs and nymphs. Tree, hedge and plant barriers will often prevent the beetles from flying into the field. For the same reason intercropped or mixed cropped plants suffer less.

WHITEFLY: (*ALEYRODIDAE*)

WHITEFLY

Host plants

Whiteflies favour beans, brinjals, cotton, crucifers, cucurbits, okra, potatoes, pumpkin, oranges, sunflowers, tobacco and tomatoes.

Damage

The nymphs suck the sap causing yellowing of the leaves which weakens the plant. In the case of severe infestations the leaves may dry and drop off.

Life cycle

The female generally lays the oval white eggs in a circle on the underside of tender young leaves. Each egg is attached to the leaf by a short stalk. These hatch into flattened oval nymphs that can creep about at first but once a feeding site is found, they lose their legs and become static. The nymph moults 3 times and then becomes a pupa before turning into an adult.

Identification

The adults are very small, white, winged insects which are often clustered together on the plant. They can be seen easily by eye usually hiding on the underside of plant leaves. The whiteflies will dart away when the plant is shaken. The nymphs appear as minute yellow dots among the adults.

RECOMMENDED REMEDIES

Planting African marigolds, apple of Peru, nasturtiums or rhubarb next to or near susceptible plants is said to deter whitefly.

Mint and pigeon pea are useful decoy or trap crops.

Remedies specifically recommended in the literature are: Ash (A2 ix, xi); Clay etc. (A10 i, iv, v); Glues (A13); Hand picking (A15 ii); Oil (A21 i, ii, iii)— see warning; Potassium permanganate (A22); Salt (A 23 i); Soap (A25 i, ii, iii); Water (A31 i); Onion (B 1.1); Chilli (B 1.4); Tomato (B 1.12); Rhubarb (B 1.19); Blackjack (B 2.8); Lippia (B 2.17); Whitefly (C15).

Tobacco has been applied successfully both as a dust and as a spray (with soap added).

Good results have been obtained locally with Tephrosia (B 2.26) but any of the insecticidal plants mentioned in B5, particularly sprays from Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26) should be worth testing.

Spray particularly on the underside of plant leaves.

Nothing appears to be known concerning the effectiveness of repellants (B6).

Checks

The little whitefly is windborne and has a strong preference for certain plants particularly tomato, mint and beans, therefore barriers and trap cropping are good methods of controlling them. They prefer humid, windless corners, nurseries and so on. Many small and large insects predate on them and the presence of a varied insect life should be encouraged. Check the soil for phosphorus deficiency.

WHITE GRUB: (*SCARABAEIDAE*)

WHITE GRUB

Host plants

The grubs feed on roots of many plants. Attacks on cotton, crucifers, groundnuts, maize, protea, tobacco, tomatoes and grass roots have been recorded. The adult beetle of a large species called *Eulipida Mashona* has a preference for the leaves of Julbernardia globiflora and Brachystegia spiciformis trees.

Damage

The most damage is done between February and April. The plants wilt and die as the roots are eaten. At the end of the rains the grubs have a tendency to cut through the main anchor roots of maize plants causing them to dislodge. The adult beetle rests in the soil during the day and emerges at night to feed on plant leaves, making irregular holes. In the case of heavy infestations, whole plants may be defoliated.

Life cycle

The white grub is the larval stage of the Scarab 'chafer' beetle. It lives underground feeding on humus and plant roots. The adult beetle lays 30–60 eggs in the soil usually in November or December. The grub is fully grown by early winter and penetrates more deeply into the soil as the dry season advances. It then constructs an earthen cell in which to pupate and the adult beetle emerges with the first soaking rains. The whole life cycle takes about one year to complete.

Identification

The grub is a large, fleshy, C-shaped insect with a brown head, three pairs of forelegs and blueish hindparts. It is often seen when digging into heaps of manure, compost or humus-rich ground.

Adults are light to dark brown chafer beetles.

RECOMMENDED REMEDIES

This insect is a classic example of a creature becoming a pest when its main source of food in the grub stage, soil organic matter and decomposing vegetation, is reduced or removed by farming/gardening activities. Further loss of the favourite food of the adult *Eulipida Mashona*, Brachystegia spiciformis and Julbernardia globiflora leaves, has resulted from the short-sighted policy of clearing all trees from arable lands. Loss of bird and small animal life which predate on the beetle has also contributed substantially.

The insect is attracted particularly by *buried* organic matter and less so by organic amendments applied to the soil surface. This is another reason for applying zero or minimal tillage techniques — not turning-in residues but leaving compost, manures and crop residues on the surface.

However, in the case of heavily-infested ground (presumably because of heavy amounts of organic matter buried previously), turning the soil to expose the grubs and then hand picking them might be the most practical solution.

Beetle: the beetles are large, hard-shelled and hide underground during the day. Nevertheless this is perhaps the most vulnerable stage of the insect as it can be readily caught at night by light traps: Various insects (C17). Hens etc. (A16) are useful for digging them out during the day.

Eggs: during the egg laying period November–December Hens etc. (A16) can easily dig the eggs from the soil. In addition spray the following well into the soil: Pyrethrum (B 1.6), Tobacco (B 1.17), the Rain tree (B 2.19), Cork bush (B 2.20) and Tephrosia (B 2.26).

Grubs: remedies specifically recommended in the literature for grubs are: Hens etc. (A16); Garlic (B 1.2); Tomato (B 1.12); Syringa (B 1.15) and Mexican poppy (B 2.5). A strong mixture of Pyrethrum and Tephrosia should be tried if all else fails.

The grubs are large, hardy and protected by the soil in which they hide. They are most vulnerable in summer as they bury more deeply into the soil as the winter advances.

Checks

Ensure sufficient soil humus, particularly old root systems such as can be encouraged by zero or minimum disturbance (tillage) of the soil. Are there enough Brachystegia spiciformis and Julbernardia globiflora trees in the vicinity to attract the Mashona beetle and to act as wind breaks? Encourage the return of birds particularly and tolerate a certain level of activity of predatory small animals such as moles, rats, hedgehogs, mongooses and so on.

Diseases

BACTERIA

Host plants

The leaves, fruits, stems and roots of a wide variety of plants. The following have been mentioned in local texts:

Bacterial blight: beans, potatoes, tomatoes.
Bacterial canker: apricots, cherries, peaches, plums, tomatoes.
Bacterial spot: almonds, apricots, cherries, mangoes, peaches, plums, beans, crucifers, lettuces, peppers, tomatoes.
Common scab: potatoes.
Crown gall: apricots, asters, cherries, peaches, plums, chrysanthemums, roses.

Damage

Bacteria cause browning and yellowing of the leaves, stems and fruit of plants, with rotting of the affected parts for example, blight, canker and bacterial spot. Other bacteria attack the root systems for example, common potato scab and crown gall.

Life cycle

Bacteria are minute organisms whose cells remain separate or may join up into microscopic groups or strands. They cannot be seen by the naked eye. Parasitic plant bacteria obtain their food from the host plant and thereby weaken it. Most bacteria reproduce by a cell dividing into two parts but a few kinds reproduce by a parent cell producing a new cell. Some types of bacteria live in the soil while others live on the above-ground parts of plants. Soil-borne bacteria can be spread by surface water (erosion) or simply by soil being splashed up on to plant leaves by raindrops or irrigation sprays. Infected soil may be moved from one place to another when filling seed boxes, transplanting, or by carrying it about on dirty boots, tools, and so on. Bacteria living above ground can be transmitted by wind, insects and infected tools and plant material.

Identification

The presence of bacterial attack can be identified through the declining health of the plant, taking into account the absence of insect damage and the presence of unsightly blemishes on plant parts or abnormal growths.

RECOMMENDED REMEDIES

Bacterial diseases can be best prevented by growing healthy plants (*Part 1: Section 1 Reinstate Soil Fertility*), by rotations (*Part 1: Section 3 Re-introduce Plant Diversity*) and by hygiene and other good husbandry practices (*Part 1: Supportive Strategies*).

If serious infections are allowed to build up it may be necessary to leave the land fallow for long periods (5–10 years).

Mulching will help to minimise the spread of diseases by preventing their transmission through soil splash. For the same reason, surface irrigation is better than overhead irrigation.

Ensure that irrigation water is free from diseases and has not been contaminated by diseased plants.

Windbreaks will minimise the spread by reducing the ability of wind to carry the disease.

A treatment of seed to prevent the spread of diseases is given in Part IV A1.

Supplementary treatments

These supplementary measures have been mentioned in the literature for the control of bacterial diseases: Ash (A2 viii, xii); Burning (A9); Compost (A12 i, ii); Manure etc (A17 i, iii); Sun (A29 ii); Water (A31 iv); Garlic (B 1.2); Chilli (B 1.4); Tomato (B 1.12); Goat weed (B 2.2).

Regular routine spraying with compost extract, manure and urine mixes are considered to be among the most effective all-round supplementary measures, resulting in removal or suppression of the disease, increased plant health and greater resistance to other diseases.

Checks

Check garden hygiene, and the use of resistant plants, time of planting, and plant spacing to minimise the spread of bacterial diseases. Check mulch quantity and use of windbreaks. Scout often and apply the supplementary treatments as necessary.

FUNGI

Host plants

The leaves, fruits, stems and roots of most plants, including grasses. The following have been recorded on crops locally.

Alternaria: apples, carrots, citrus, cotton, onion, pears, tobacco.
Anthracnose: avocados, beans, coffee, grapes, guavas, mangoes, cucurbits, tomatoes, sorghum, tobacco, roses.
Botrytis Rot: grapes, groundnuts, guavas, strawberries, tomatoes.
Common Scab: potatoes.
Crown Rot: carnations, groundnuts, onions.
Damping off: (seedlings) beans, cotton, crucifers, cucurbits, carrots, peas, groundnuts, tomatoes.
Fusarium Blight & Rot: beans, cabbages, carnations, onions, potatoes, sorghum, tomatoes.
Early & Late Blight: potatoes, tomatoes.
Leaf curl: deciduous fruits.
Leaf Spots (Septoria & Cercospora): coffee, cotton, granadillas, groundnuts, lettuces, maize, pears, spinach, sorghum, sunflowers, tomatoes.
Powdery & Downy Mildew: apples, apricots, crucifers, cucurbits, deciduous fruit, grapes, mangoes, onions, peaches, pears, peas, peppers, plums, sorghum, sunflowers, tomatoes, vines, and many other garden plants.

Root Rot: avocado, citrus, parsley, sorghum, protea and other garden plants.
Rot (fruit): apples, citrus, deciduous fruits, peaches, pears, plums, vines.
Rusts: apricots, beans, coffee, cucurbits, deciduous fruit, maize, millet, peaches, plums, sorghum, sunflower, and many other garden plants.
Scab: apples, citrus, deciduous fruits, pears, pecans, beans, cucurbits, deciduous fruit.
Smuts: barley, millet, sorghum, wheat.

Damage

Very many fungal diseases attack all parts of plants with loss of appearance of the produce, declining yields or loss of the plant. Most plants are susceptible to fungal diseases of one type or another, each type of fungus having a specific range of host plants.

Life cycle

Fungi are organisms which obtain their nutrients by drawing them from other plants. Fungal diseases are transmitted mainly by spores which may be carried to new sites by wind, water, soil, insects, birds, animals and by man *via* his tools and activities. Many fungi favour moist conditions.

Identification

Fungi can often be seen as moulds on the surfaces of fruit and leaves but may also appear as black or brown spots and blemishes on leaves, growing tips, blossoms and fruit, the fruit eventually rotting. Root rot can be identified by inspecting part of the root system when a plant wilts without any apparent cause.

RECOMMENDED REMEDIES

Fungal diseases can be prevented best by growing healthy plants (*Part I: Section 1 Reinstate Soil Fertility*), by rotations (*Part I: Section 3 Re-introduce Plant Diversity*) and by hygiene and other good husbandry practices (*Part I: Supportive Strategies*).

Mulching will help to minimise the spread of diseases by preventing their transmission through soil splash.

Take care not to apply a greater amount of irrigation water than necessary. When overhead irrigation is being applied, apply the required amount of water in frequent small doses to avoid the leaf being wet for long periods.

Surface irrigation (including drip) is better than overhead as overhead irrigation wets the leaves and thereby creates an ideal environment for spore development. Timing the irrigation so that the plants do not remain wet overnight will help to contain the disease.

Ensure that irrigation water is free from diseases and has not been contaminated by diseased plants.

Select well-drained lands for planting particularly susceptible

crops like potatoes and tomatoes; otherwise grow the plants on graded ridges or beds.

Windbreaks will reduce the spread by reducing the ability of wind to carry the disease.

Other useful cultural techniques are to plant mixed varieties of the same crop on the same field, or to stagger the planting dates — not planting all the crop at the same time, plant the seed moving along the field into the prevailing wind, and choosing the right plant for the particular soil in the field, for example citrus and perennial crops generally prefer soil with less than 25 per cent clay.

A treatment of seed to prevent the spread of diseases is given in Part IV A1.

Supplementary treatments

The following remedies are recommended in the literature: Ash (A2 viii, x, xii); Baking soda (A3); Biological (A4 iii); Bordeaux mixture (A5); Burgundy mixture (A8); Burning (A9); Compost (A12 i, ii); Manure etc. (A17 i, iii); Milk (A18 i, iii); Mulch (A19 i); Oil-rape seed (A21 i, ii); Potassium permanganate (A22); Soap Solutions (A25 i, ii) — some soaps only; Sulphur (A28); Sun (A29 ii); Water (A31 ii, iii, iv); Onion (B 1.1); Garlic (B 1.2); Chilli (B 1.4); Pawpaw (B 1.5); Sunnhemp (B 1.7); Sweet potato (B 1.11); Tomato (B 1.12); Syringa (B 1.15); Oleander (B 1.16); Tobacco (B 1.17); Sweet basil (B 1.18); Rhubarb (B 1.19); African marigold (B 1.20); Mexican poppy (B 2.5); Thorn apple (B 2.11); Asthma weed (B 2.12); Rubber hedge (B 2.13); Wild tobacco (B 2.22); Wild basil (B 2.23); Castor oil (B 2.24); Mexican marigold (B 2.25) and Pigweed (B 4.4).

Bordeaux mixture has been found useful in the treatment of rusts on coffee.

Regular routine spraying with compost extract, manure and urine mixes are considered to be among the most effective all-round supplementary measures, resulting in removal or suppression of the disease, increased plant health and greater resistance to other diseases.

The infected leaves and fruit should be taken off the plant and burned, buried deeply or composted. Seed from diseased fruit or vegetables should not be re-sown as they will be infected with the disease.

Checks

Check garden hygiene, the use of resistant plants, time of planting, plant spacing and watering regime to minimise the spread of fungal diseases. Check mulch quantity and use of windbreaks. Scout often and apply the supplementary treatments as necessary.

VIRUSES

Host plants

Maize Streak Virus: maize.

Mosaic: beans, crucifers, cucurbits, potatoes, tomatoes, roses and many other garden plants.

Tomato Spotted Wilt: chrysanthemums, dahlias, tomatoes.

Damage

Leaves and stems of plants may become discoloured or distorted affecting photosynthesis and nutrient uptake with loss of yield or death of young plants. Fruit may ripen unevenly and be deformed or blemished.

Life cycle

Unlike bacteria and fungi, viruses cannot reproduce themselves. They multiply by causing the cells of the host plant to produce new copies of the virus. In doing so, the virus produces toxic symptoms in the host plant and depletes it of nitrogen compounds. Plant viruses are usually transmitted from one plant to another by sucking insects both below and above the ground but can also be spread by grafting, by seeds and pollen, and via infected cutting and pruning tools.

Identification

The removal of nitrogen compounds by the virus may result in the first symptoms being a yellowing of the leaves as in mosaic or maize streak viruses. But toxic effects caused by the presence of the virus may show up first, in which case brown spots may be seen on the leaves, for example, tomato spotted wilt.

RECOMMENDED REMEDIES

Viral diseases are extremely difficult to control once they are present.

If serious infections are allowed to build up it may be necessary to leave the land fallow for long periods (5–10 years).

They can be prevented best by growing healthy plants (*Part I: Section 1 Reinstate Soil Fertility*), by rotations (*Part I: Section 3 Re-introduce Plant Diversity*) and by hygiene and other good husbandry practices (*Part I: Supportive Strategies*); including the use of virus-free plants and seeds.

In addition the number of sucking insects such as aphids, leafhoppers, mites, scale, tip wilters, thrips and whitefly should be kept strictly under control (not eliminated entirely); and their movement restricted by windbreaks.

In the case of viruses carried within the soil by nematodes and fungi, the best policy is to ensure a well-balanced soil-life population by minimal soil disturbance, compost additions, mulching and rotations.

Supplementary treatments

The following supplementary measures have been mentioned in the literature for the control of viral diseases: Ash (A2 viii); Burning (A9); Compost (A12 i, ii); Manure etc. (A17 iii); Milk (A18 i, ii); Mulch (A 19 i); Oil-mineral-paraffins (A21 i, ii); Chilli (B 1.4); Tobacco (B 1.17); Asthma weed (B 2.12); Wild tobacco (B 2.22); Snow berry (B 4.15).

Regular routine spraying with compost extract, manure and urine

mixes will help to build up plant resistance.

In the case of mild attacks sprays made with ash, milk or any of the plants mentioned above can be tried.

In case of serious infection or even mild infections failing to respond to the supplementary treatment, all infected material should be removed and burned.

Checks

Prevent outbreaks by checking that the soil is in optimal condition, the crops are healthy, that the varieties selected are resistant to the prevalent viral diseases; and that there is sufficient plant diversity in the form of rotational and other practices. Minimise the spread of diseases through garden hygiene, time of planting, and plant spacing. Check mulch quantity and use of windbreaks. Scout often and apply the supplementary treatments as necessary. Remove and burn badly-infected plants.

Other Pests and Diseases

The following list gives the references to the treatments mentioned in Part III for pests not covered in detail in the foregoing text. In addition, references for specific diseases are given.

PESTS

Animals (general): A17 iv-vii; A20; B 1.2.
Ants (Leaf Cutting): B 2.24.
Aphid (Woolly): B 1.3; B 1.10; B 4.3.
Baboons: A17 vi; C5.
Beetle (Asparagus): B 1.12.
Beetle (Bean Leaf): B 2.16.
Beetle (Black Carpet): B 2.6.
Beetles (Flea): B 1.17.
Beetles (general): A10 i-iii; A25 ii; B 1.2; B 1.15; B 1.16; B 1.20; B 2.5; B 2.8; B 2.10; B 2.15; C3; C4.
Beetles (Mexican Bean): B 2.21.
Beetle (Red Pumpkin): B 4.6.
Beetles (stored produce): B 2.2.
Birds (general): A20; B 1.2; C5.
Bilharzia snails: B 1.17; B 2.6; B 2.14; B 2.22.
Blackflies: C17 iii.
Blowflies: B 2.25.
Buck: A17 iv-vii; A18 iv; B 2.1; C5.
Butterflies (general): C3.
Bugs (general): B 1.5; B 1.15; B 2.5; B 2.18.
Cabbage butterfly/worm: A18 i; B 1.1; B 1.12; B 3.5; B 4.6.
Cabbage root fly: A2 iii; A23 ii; B 1.4; B 1.15; B 2.8; B 3.6; C8 iii.
Canker moths: A26 ii.
Caterpillars (general): A2 i; A10 i-iv; A13; A17 iii; A21 i, ii; A22; A23 ii; A24 i; A31 i; B 1.2; B 1.5; B 1.12; B 1.14; B 1.15; B 2.5; B 2.6; B 2.17; B 2.18; B 2.24; B 2.25; B 3.1; C7.
Caterpillars (hairy): B 2.9; B 2.23.
Caterpillar (lawn): A19 ii; B 1.17.
Caterpillars (small): B 1.19.
Cockroaches: B 1.12; B 4.13.
Codling moth: B 1.10.
Cotton stainer: B 2.2; B 2.16.
Crawling pests (general): A14; A31.
Crickets (armoured): A25 i-iii.
Crickets (general): B 2.8; C8 ii.
Dusty surface beetle: C8 ii.
Eggs (general): A7 ii, iii; A10 i, v; A15 ii; A21 i-iii; A31 i, ii.
False codling moth: B 1.2.
False wireworm: C8 ii.
Fleas: A21 v; B 1.17; B 2.22; B 2.24; B 2.25; B 4.1.
Flies (general): A 17 ii; A21 v; B 1.12; B 1.14; B 1.16; B 1.18; B 2.21; B 2.23; B 2.25; B 4.2; C9; C17 iii.
Flies (house): B 1.2; B 2.2; C9.
Flies (vinegar): B 2.2.
Gnats: C17 iii.
Grubs (general): B 1.2; B 1.12; B 1.15; B 2.5; C7.
Hares: A17 vi; C13 iv.
Head lice: B 2.3.
Hoppers (general): B1.15.
Larvae (general): A7 ii, iii; A10 i-v; A21 i-iii; A31 i-iii; B 1.12; B 2.10; B 4.2.
Larvae (leaf-eating): B 2.14.
Leaf hoppers B 1.6; B 2.4; C17 iii.
Leaf miner; A25 ii; B 1.17; B 2.15; B 2.26; C10.
Lice: B 2.24; B 4.13.
Locusts: A20.
Maggots (general): B 1.18; B 1.19; B 2.23; B 2.25.
Maggots (onion): B 1.4; B 3.1-3.4.
Mealy bugs: A17 iii.
Melon worm: B 2.6; B 2.16.
Mice: B 1.1; B 1.2; C13.
Mites (general): A10 vi; A17 iii; B 1.12; B 2.24; B 3.6.
Mites (on chickens): B 4.1.
Moles: A20; B 1.1; B 1.2; B 1.15; B 2.24.
Mosquitoes: A21 v; B 1.2; B 1.18; B 2.10; B 2.13; B 2.23; B 2.25; B 4.2.
Moths (general): A19; C3; C12.
Peach borer: B 1.2.
Potato moth: B 1.18; B 2.23.
Psyllids: A25; A17 xi.
Rats: B 4.13; C13.
Rabbits: A17 vi; C13 iv.
Rodents (general): B 1.16.
Root maggots: A2 iii.
Seedbed pests (general): B 2.23.

Soft-bodied insects (general): A2 i; B 1.14; B 1.19.
Shield bugs: B 2.26.
Squash bug: A7 iv; A10 ix; A15 ii; B 1.3; C14.
Stemborers (general): B 1.15; B 2.18.
Ticks: A21 v; B 1.1; B 1.2; B 1.17; B 2.22.
Tomato fly: B 1.1.
Tomato hornworm: A15 i; B 1.12; B 2.21.
Wild pig: C16.
Weevils (banana): C2.
Weevils (general): A2 iv-vii; B 1.15; B 1.16; B 2.5; B 4.3; C17 i.
Weevils (maize): B 2.2.

DISEASES

Anthracnose: B 2.24.
Apple scab: A17 iii.
Apple mildew: A17 iii.
Bacterial wilt: B 1.12.
Bean rust: B 1.2.
Black spot: A5.
Botrytis: A22; A28.
Brown patch: B 2.24.
Canker: A10 viii.
Club root: A2 iii; A10 x; B 1.19.
Coffee berry disease: B 2.25.
Damping off: A29 ii; A31 iii; B 1.1; B 2.24.
Downy mildew: A5, A17 iii.
Gooseberry mildew: A17 iii.
Late blight: A12, B 1.1; B 1.20; B 2.25.
Leaf curl virus: A5; A12; B 1.17; B 2.22.
Leaf spot: B 1.1; B 1.5; B 1.11; B 1.16.
Mildew (general): A2 x; A3; A8; A12; A17 i, iii; A18 iii; A22; A29; B 1.2; B 1.19; B 2.25.
Mosaic virus: A18 i.
Powdery mildew: A5; A8; A12; A17 i, iii; A28; B 1.5.
Rice blast fungus: B 1.11.
Root rot: B 2.24.
Rusts: A3; A5; A8; A17 iii; A28; B 1.5; B 1.17; B 2.22.
Scab: A17 iii; B 1.2.
Tomato blight: A5; A8; A17 iii; B 1.2.
Vine powdery mildew: A17 iii.

PART III

REMEDIES FOR PROTECTING FIELD CROPS

A Miscellaneous Substances and Methods

Where spraying equipment is not available, the liquid can be flicked on to the plant with paint brushes, brooms or brushes made from local plants.

A1: AROMATIC PLANTS

Materials
Leaves of any strongly-smelling plants like gums, lantana, khaki weed, tomato or any herb.

Targets
Any insect.

Methods
Make up a spray from the leaves of strongly-smelling plants either using 1 plant or mixing 2 or more together. The strong smell will repel pests. Garlic, chilli and onion sprays are recommended particularly.

The plant material is dried, ground to a powder, mixed with boiling water and allowed to cool before spraying. Recommended mixes vary from 20–500g per litre of water.

Frequency
Spray just before peak infestation is expected in early summer and repeat as often as necessary depending on the number of pests evident that year. More applications will be needed during the rain as the substance will be washed off the plants.

Warning
Some crops are damaged by juice from other plants, therefore watch out for signs of damage (usually deformed leaf growth), try to identify the problem plant and leave it out in future; or simply avoid using it on that type of crop.

A2: ASH

Targets
Soft-bodied insects including aphids, birds, cabbage root fly, caterpillars, cutworms, grasshoppers, eggs, larvae, nematodes, potato moths, pupae, root maggots, slugs, snails, squash bugs, stalk borer, termites, weevils and insects in general; diseases with mildew and club root being specified; and other pests.

Materials
Wood ash from plant parts. Ash from specific vegetation has been found to be more effective against specific insects. Ash from acacia nilotica, casuarina, cyprus, combretum imberbe, eucalyptus, mango wood, finger millet, rice trash, spirostachys africana and tamarind have been found to be particularly effective as disinfectants or as general insect repellents — see *warning* that follows.

Method

i Dust ashes evenly on to vegetables to dehydrate soft-bodied insects or into the funnel of young maize plants to kill stalk borer. Dusting crop leaves with the ashes of combretum imberbe and spirostachys africana are said to control aphids and grasshoppers.

ii Spread ashes thickly around plants or seed beds to deter soil pests: cutworms, eggs, larvae, pupae and so on; preferably in a 150–200mm wide trench 20–50mm deep to deter slugs and snails. The ash of combretum imberbe and spirostachys africana is said to control cutworm when mixed with the soil in the planting holes.

iii Spread around the roots of radish, onions, cabbage and other crucifers and cover lightly with soil as a protection against cabbage root, fly maggots and club root.

iv Spread over the soil surface as a mulch to control nematodes and weevils.

v Incorporate into the soil during planting of any plants including in forestry nurseries to protect seedlings against termite attack. This treatment has been found to protect sweet potato from the sweet potato weevil.

vi Heap ashes around the base of tree trunks to prevent them from termite attack.

vii Ashes mixed with compost and dug into the soil can control weevils and nematodes and greatly improve soil fertility.

viii Dip cuttings into ashes mixed in water to reduce diseases and increase the percentage take.

ix Spray with wood ash mixed with soapy water and/or lime as a general insecticide.

x Spray with a mixture of 1 heaped tablespoon of wood ash stirred vigorously into 1 litre of water, leave overnight, strain to remove solids, mix with 1 cup of sour milk and add 3 litres of water. This treatment has been found effective against mildew — see also *milk treatments* — and a range of pests and their eggs.

xi Wood ash mixed in lime sprays is said to increase its potency against certain insects like squash bugs. Allow mixture to stand for 1–2 days before use.

xii Soaking seed in wood ash and water for 24 hours before planting gives protection against fungal and bacterial diseases.

xiii Soak seeds in ashes mixed with water or with the juice or leaves of any strongly aromatic plant added to the water to deter birds from eating the seed (Maize seed has been identified). Test the effect of new aromatic plant material on germination using small quantities of seed before using it as a general treatment; some strong-smelling plants can affect the viability of seed.

Frequency
Apply as frequently as necessary. More applications will be needed for surface ashes (required as a dry barrier) during wet or windy periods. Dusts are said to be more effective applied to plant leaves when they are moist from rain, irrigation or dew.

Warning
Wood ash contains variable amounts of caustic potash so it should not be used on hot days and on tender plant growth. Do not allow ashes to touch the stems of plants, particularly seedlings.

Ashes should be allowed to cool before use. Do not use coal ash.

The milky latex from spirostachys africana should not touch the skin or enter the eyes. Protect eyes from sawdust and ashes.

A3: BAKING OR WASHING SODA

Materials
Baking soda or washing soda, water and soft soap.

Targets
Fungal diseases (mildew and rust mentioned particularly) and scale.

Method
Spray with a mix of 100g of baking or washing soda with 50g of soft soap. Dilute with 2 litres of water or more.

Frequency
Spray only once preferably or leave as long a gap as possible (several months) between applications.

Warning
Use immediately but never during very hot weather. Avoid spraying the leaves and flowers as the spray is known to damage plant tissue. For the control of scale, spray onto fruit trees when they are dormant (leafless).

A4: BIOLOGICAL CONTROLS

Materials
Cultural methods detailed in Part I should be applied. See summary at the end of Part I for quick reference. Apart from cultural methods, some simple biological controls can be applied as follows.

Targets
Insects in general.

Methods
i Spray with a mixture made up of a handful of the pest insects crushed and mixed into 10 litres of water. Add a little liquid soap. Leave for 12–24 hours. Pests of the same species have been found to evacuate crops treated in this way. The insect bodies remaining after sieving the liquid can be left in open containers (jars, tins etc.) in the garden as the smell will continue to repel the insects.

This treatment is said to be effective on armyworm and other caterpillars, millipedes, saw fly, slugs and various bugs; but less successful on grasshoppers and locusts.

ii Spray with a mixture made up of a handful of the insects which are showing signs of distress from a natural disease. This spreads the disease to the healthy insects of the same species, or even to other species.

iii Control the humidity by altering the spacing distance between plants. Close spacing discourages red spider mite while wide spacing discourages fungal and other diseases.

Frequency
Treatment i may have to be applied several times, particularly during the rains. Treatment ii normally need only be applied once but monitor the rate of spread of the disease and assist it with further spraying if necessary.

Warning
Wear plastic or rubber gloves as certain insects contain harmful substances, for example, blister beetles.

A5: BORDEAUX MIXTURE (SEE WARNING)

Targets
Fungi: powdery mildew, downy mildew, tomato and potato blight,
black spot on beans, leaf curl on peaches, rust and as a general fungicide.

Method
Mix 90g of blue copper sulphate with 4.5 litres of water in a non-metallic container. In another non-metallic container, mix 125g of slaked lime (builder's lime) with 4.5 litres of water. Stir and make sure the lime is well dissolved. Mix the two solutions and stir well. Test the mixture by putting an old nail in it for 30 seconds. If it turns blue there is not enough lime in the mixture or the lime is not sufficiently dissolved in the water. Allow the lime to soak longer, otherwise the mixture will burn the leaves. Use the mixture immediately.

Frequency
Apply twice at 7-day intervals but only if necessary.

Warning
Do not use regularly in the same place as it kills many beneficial fungi and pest predators as well.

Some plants are sensitive to copper and sulphur so test first if uncertain. At high concentrations the mixture is toxic to soil organisms, insects, plants, animals and humans.

A6: BRUSHING

Materials
A stiff brush.

Targets
Crawling insects and swarms.

Methods
i Swarms of beetles and caterpillars can be swept into piles with a stiff broom and destroyed.

ii Insects, larvae and eggs can be swept from leaves, branches and trunks of fruit trees with a stiff brush.

Frequency
Carry out as frequently as necessary.

Warning
Protect the eyes (wear dark glasses) from falling dirt, insects and so on. Some insects can seriously injure the eyes.

A7: BUILDER'S LIME (SEE WARNING)

Materials
Builder's lime (quicklime), which is called slaked lime after water has been added.

Target
Eggs, larvae, slugs and snails, and squash bugs.

Method
i Dust over nursery floors, or where there is no plant material, to kill slugs and snails.

ii Brush freshly-mixed lime and water on to the hardened bark of mature trees to kill eggs and larvae on the trunk. Old bark under which insect larvae and eggs can be hiding should be scraped off first with a wire brush.

iii Spray lime and water mixtures onto tender plant parts (leaves etc.) only after it has been allowed to stand for a few days until the heat of hydration has worn off — see also *Bordeaux mixture*.

iv Mix builder's lime and wood ash with water to the consistency of thin soup, allow to stand for 1–2 days before spraying on squash bug.

Frequency
Treatment i may need to be repeated every time the slug and snail population increases. Treatment ii can be applied once only in winter but should be re-applied every few months during the rainy season.

Warning
Do not allow builder's lime-dust onto the skin or into the eyes as it burns on contact with moisture. Do not apply as a dust to tender plant parts such as leaves for the same reason.

A8: BURGUNDY MIXTURE (SEE WARNING)

Materials
Copper sulphate, washing soda and water.

Targets
Fungal diseases.

Method
Dissolve 200g of copper sulphate in 9 litres of water. Then dissolve 30g of washing soda in 9 litres of water. Mix the two and add another 4.5 litres of water. Spray on affected plants.

Frequency
Use only once a year at the most.

Warning
Use with even greater caution than Bordeaux mixture. Apply only to dormant fruit trees or vines i.e. woody species not in leaf. Some plants are sensitive to copper and sulphur so test first if uncertain. At high concentrations the mixture is toxic to soil organisms, insects, plants, animals and humans.

A9: BURNING (SEE WARNING)

Materials
Infected plant material.

Targets
All pests.

Method
Burn all affected plant material when dry or mix with dried inflammable material if green.

Frequency
Burn until all infected material is reduced to ashes. The ashes will then be safe to use for further pest and disease control both in the field and in storage.

Warning
Ensure that the fire does not spread. Great environmental damage is caused to the pest/predator balance (see *Armyworm* in *Part II*), to the soil (loss of organic matter and soil life), and to the atmosphere (greenhouse effect) by both intentional and unintentional bush fires. Even small fires may be prohibited in future should the situation worsen. Keep small children away from the fire.

A10: CLAY, LIME AND OTHER POWDERY MATERIALS

Materials
Any fine powdery substance such as clay, crushed laterite, agricultural lime, flour, chalk, rock dust and so on.

Targets
Ants, aphids, beetles, canker, caterpillars, codling moths, cutworm, eggs of insects, larvae (any), mites, scale, slugs, snails, squash bugs, stink bugs, thrips, tip wilters and whitefly; club root.

Methods
i Dust the fine material onto the leaves, the insects (aphids, mites, thrips, whitefly) or their eggs, to suffocate them. Lime dusted over loopers worked very well; lime dusted onto small black slugs was effective and has been recommended also for controlling small beetles.
ii Leaves can be dusted with clay and laterite to protect them from attack by sucking insects (aphid, mites, scale, stink bugs, tip wilters and so on), but the treatment is only temporary, especially during the rains.
iii Dust around the base of the plants to protect them from any insect trying to crawl up the stems (ants, slugs, snails, cutworm, beetles and so on); or trying to lay eggs in the soil near to the plant.
iv Spray with a mixture of the powdery material in water. Add material (clay etc.) and stir thoroughly until the mix is like very thin soup. Allow to stand for a few minutes and then pour the liquid into another container so leaving any solids behind. Stir in a little soap to give a slight froth on the surface. Apply with a watering can (with sprayhead) or splash on with a large paint brush or bush-broom. Do not use sprays with fine nozzles as they will get blocked. Apply during a dry spell so that the liquid has time to evaporate and the fine dry material hardens around the pest. A lime spray worked well on loopers — see also *dusting i* — and flour sprays have worked well on aphids, mites, whitefly and thrips.
v Spray with a mixture of 4 cups of flour, half a cup of sour milk and 20 litres of water to destroy eggs, larvae and adult aphid, mites, thrips and whitefly.
vi Some old gardening books recommend a lime-water spray for controlling mites such as red spider mite. Lime water is the clear water remaining on top after all the lime itself has settled to the bottom of the bucket.
vii Mix clay with fresh cattle manure to form a paste and paint the mixture on trunks of fruit trees against codling moths and other pests, and to seal the fresh cuts on the trees after pruning.
viii Fill wounds in trees, including those caused by cutting out canker, with moist clay rammed in tight (a little cement, putty or builder's lime can be added for durability) and the surface smoothed over.
ix Wood ashes mixed in lime sprays into a thin soup is said to increase its potency against certain insects like squash bugs. Allow mixture to stand for 1–2 days before use.
x Liming acid soil is said to reduce the incidence of cutworm and club root.

Frequency
The treatments are effective for short periods and must be repeated as often as necessary, depending mainly on the weather and the presence of insects. Lime dusts are said to be more effective when applied to the plant leaves when they are moist from rain, irrigation or dew.

Warning
Frequent use of clay preparations will have no harmful effect on soil with lots of organic matter in it but clay and other powders may increase surface crusting on soils in poor condition. Builder's lime can be used mixed with water as a spray and applied after several days when the heat of hydration has worn off; but it should never be used as a dust on leaves or they will be scorched.

Application of agricultural lime will at first benefit acid soils, particularly if inorganic fertilizers have been used in past years, but the soils may become overly alkaline if heavy dusting is repeated too often.

Do not allow lime dust to touch the stems of seedlings.

A11: COFFEE GROUNDS AND TEA LEAVES

Materials
As above, either waste or fresh.

Targets
Insects in general, slugs and snails.

Method
i Spread on the surface of the soil around the plants to protect plants from slugs and snails.
ii As sprays, fairly strong brews made from tea leaves and coffee grounds are said to have general insecticidal properties.

Frequency
Use as frequently as necessary.

Warning
Prolonged use may create acid conditions in the soil.

A12: COMPOST

Materials
Well rotted-down compost made with plants and animal manures.

Targets
Most pests and diseases (by giving the plants greater resistance to attack). Rusts are said not to respond to compost sprays.

Method
i Spray the plants and soil with a mixture of 1

shovelful of compost in 20 litres of water after the mix has been standing for 3 days to several weeks. For smaller amounts put 1 sock full of compost (about 0.5 kg) in a 20 litre bucket. Apply as a foliar spray to supply the plant with much-needed nutrients to help it withstand attack and to increase yield. The longer the mix is left to stand, the stronger and more effective it becomes. The spray should be applied once a week when the plants are young.

ii Increasing the compost level in the soil protects the plant against all pests and diseases. The compost is best applied to the soil surface for reasons discussed in Part 1.

Frequency
Apply the compost spray as a preventive measure and as a regular weekly treatment once the disease appears. Feed the plants with a palm full of compost at planting, before fruiting and after every harvest or cutting.

Warning
None known.

A13: GLUES

Materials
Any water-soluble glue, particularly those obtained from plants. Water from boiling potatoes and cassava, if it contains sufficient concentration of starch.

Targets
Aphids, caterpillars, spider mites, thrips and whitefly.

Method
Spray a very weak solution of a water-soluble glue to suffocate the insects. The strength of mixes vary widely according to the strength of the glue available but the diluted solution should leave a thin skin coating on the plant when the solution has dried.

Warning
None known.

A14: GREASE

Materials
Any thick grease.

Targets
Ants and any crawling pest in the orchard or nursery like fruit fly larvae, slugs, snails, beetles, caterpillars and so on.

Method
i Wrap tin foil or durable plastic around the tree trunk and smear it with grease forming a barrier ring around the trunks of fruit trees. Fold over the top of the foil or plastic to form an overhang to protect the grease from being washed off by rainfall.

ii Put a wide band of grease directly onto the wood or metal of nursery tables to prevent crawling pests from reaching the seedling trays.

Frequency
Check the grease every week to ensure that it is intact.

Warning
Do not place the grease directly on to the surface of the trunk and branches of young trees otherwise they will be damaged and may even die.

A15: HAND PICKING

Materials
Gloves are sometimes advisable — see *warning*.

Targets
Many insects and chrysalises.

Method
i Large insects can be picked off the foliage by hand and fed to poultry, destroyed or thrown into the bush.

ii In the case of heavy infestations by small insects, eggs or larvae, whole leaves can be nipped off and disposed of or the insects crushed on the plant by rubbing over them with the fingers.

iii Children were able to fill a 500ml jam jar each per day with grasshoppers that they chased and caught by hand — see also *Beetles, butterflies etc C3* for use of nets.

iv Cutworms, slugs and snails can readily be seen and hand picked at night by torch or lamplight.

Frequency
The treatment is repeated as often as possible.

Warning
Wear thick gloves when dealing with blister beetles, hairy caterpillars or any stinging insect.

A16: HENS, BANTAMS AND DUCKS

Materials
Hens, bantams or ducks, a mobile coop, some chicken wire and string.

Targets
Almost all insects.

Method
Hens and bantams will catch and eat the most troublesome pests including beetles, caterpillars, cutworm, grasshoppers, and snails. They can run quickly to catch flying insects and their scratching will uncover the larvae, pupae and eggs of many pests hiding in the soil. While feeding on the pests, they also manure the ground.

There are a wide variety of ways in which fowl can be used. They can be allowed to roam freely in orchards, or on lands not yet planted, or where hardy crops are growing which will not be damaged by the hens either feeding from them or scratching around them. Alternatively, they can be cooped up in portable pens built to the exact size of the garden beds; or a mobile fence can be used to confine the hens to the required area. The services of hens and bantams may be required urgently away from home with no time to organise fencing. In this case they should be transported to the site as humanely as possible. Once there, a 3 metre length of string is tied to one leg of each hen, which enables them to be easily caught at the end of the day.

Ducks are particularly useful for removing slugs and snails.

Frequency
The hens/bantams can be confined on garden beds to clear them of insects prior to planting. They can be concentrated around the foot of fruit trees in early spring and throughout summer to clear fruit fly larvae from the soil and the grub from the fallen fruit.

Warning
Hens and ducks, particularly, can do considerable damage to seedlings by eating them or by digging them up during their scratching activities. Therefore do not allow them near seedbeds. Bantams usually prefer insects to vegetation and a flock which does not eat any leaves can be developed simply by getting rid of any bantam showing a taste for 'greens'. They are great scratchers, however, and should be kept away from young and/or delicate plants.

In winter when green material and insects are scarce, fowl can do much damage to crops. They require 'herding' at such times.

A17: MANURE, DUNG AND URINE

Materials
Cow, donkey, goat, predatory animal and poultry manure; human and animal urine.

Targets
Animals, aphids, bagrada bugs, birds, caterpillars, codling moths, cutworm, fruit flies, grasshoppers, mealy bugs, mites and thrips, fungal, bacterial and viral diseases.

Method
i Spray with a mixture made up of 1 shovel full of dry cow manure mixed thoroughly into 10 litres of water after it has been stirred once daily for 14 days. Clay dust can be sprinkled into the bucket to reduce smells and to add useful minerals. Dilute the mixture 3–5 times before spraying. This fermented dung water will repel aphids when applied to plant leaves and protect plants from cutworms when sprayed on the soil surface around seedlings. It also acts as a foliar nutrient when sprayed on leaves thus overcoming nutrient deficiencies in the plant and thereby increasing the plant's resistance to bacterial and fungal diseases. The liquid also acts as a fertilizer when sprayed on the soil.

A shovelful of fresh donkey manure mixed in a bucket of water and left overnight is said to be effective as a spray for aphids, bagrada bugs and grasshoppers.

ii Spray leaves and fruit with a mix of 1 part burnt cow dung to 2 parts water to repel aphids and flies (including fruit flies).

iii Spray with a mixture of 1 part urine (human or animal) to 1 part water to prevent aphid, caterpillars, cutworm, mealy bugs, mites, thrips, and for protection against fungal, bacterial and viral diseases. Spray on a warm day and use as a *preventive* measure. Weaker sprays of 1 part human urine to 4 parts water have been recommended for fungal diseases: apple scab, apple mildew, gooseberry mildew, downy mildew, vine powdery mildew and others.

iv Paint a mixture of clay and cattle manure onto the trunks of fruit trees to protect them from codling moths and other pests. Wood ash can also be added to this mixture. The mixture can be applied to protect fresh cuts after pruning and to repel animals from eating the bark or browsing on the leaves.

v Paint tree trunks with a thick soupy mixture of fresh dung (of the animal to be repelled) stood in water for 3 days.

vi Paint tree trunks with a mixture of goat, cow, poultry manure, clay dust and animal urine at monthly intervals to repel baboons, hares, buck, goats and rabbits.

vii Spray plants with liquid goat manure to repel hares and buck; or hang up bags of manure obtained from predatory animals (cats, dogs, lion and so on).

viii Manure, dung and urine added to the soil improves soil fertility and protects plants from many pests and diseases.

ix Spraying with cow urine that has been standing for two weeks and diluted with 6 parts of water is said to control stalk borer (presumably the eggs and new caterpillars).

x Soaking seeds for 24 hours in cow dung mixed with water is said to prevent birds from digging them up afterwards.

Frequency
Apply as often as required. The protection is needed most in the winter when there is a shortage of green material in the surrounding bush.

Warning
Vegetables or fruit sprayed with these mixtures must be washed thoroughly before consumption. Undiluted urine will burn plant leaves and will render soil toxic if used too often.

A18: MILK

Materials
Milk, paraffin, soil and water.

Targets
Fungal and viral diseases in general with blights, mildews, mosaic viruses on tomato, tobacco, sugar cane and sorghum being mentioned particularly; spider mites, caterpillar eggs on crucifers, and buck.

Method

i Spray every 10 days with a mixture of 1 litre of milk to 10–15 litres of water to control mites, blights, mildew, mosaic virus and other fungal and viral diseases on a wide range of plants. This spray is said to also control spider mites and caterpillar eggs on the crucifer family when sprayed every 3 weeks.

ii Sprays of skimmed milk have been used to control many viral diseases.

iii Spray with a mixture of 1 heaped teaspoonful of wood ashes stirred vigorously into 1 litre of water, leave overnight, strain to remove solids, add 1 cup of sour milk and add 3 litres of water. This treatment has been found effective in controlling mildew.

iv Painting a mixture of soil, sour milk and paraffin to halfway up tree trunks has been found to deter buck from eating the bark. This treatment was effective for 2–3 weeks. Protect the mix from being washed off by heavy rain.

Frequency
Frequencies are given above as appropriate.

Warning
None known.

A19: MULCH

Materials
Dead plant material: crop residues, hay, leaves, weeds etc. and tobacco leaves.

Targets
Cutworm, grasshoppers, ground beetles, lawn caterpillar, moths, nematodes, slugs and snails, termites, thrips and a wide variety of pests and diseases.

Method

i Cover the soil with a thick layer of mulch, one finger deep preferably. The mulch should consist of as wide a variety of plant material as possible (dry). To repel termites, include banana stems and mixtures of aromatic plants and weeds such as lantana, Mexican marigold, gum tree leaves and so on. Mulches of aromatic herbs are recommended for protecting plants from attack by cutworm, ground-beetles, thrips, slugs and snails. Covering bare soil with mulch discourages grasshoppers, moths and certain beetles from laying their eggs in the soil. Building up humus reduces numbers of harmful nematodes.

ii A mulch of tobacco leaves or dust will control cutworm, lawn caterpillars, thrips, slugs and snails and many other insects; but does not harm many beneficial ones such as earthworms.

Frequency
Add to the mulch whenever its depth decreases. It may need to be added to about 4–6 times per year.

Warning
Before applying the mulch, make raised beds or ridges on any soil prone to waterlogging. Do not use green plant material on seedbeds otherwise the humic acids will acidify the soil and inhibit germination of some seeds.

A20: NOISE AND VIBRATION

Targets
Locust, birds, moles and wild animals.

Method
Banging on tins and drums has been used for generations to scare pests away from crops.

Moles are particularly sensitive to vibrations in the soil. They can be driven away by frequent hammering on the ground. A simple windmill can be built with a pole attached to one arm. The pole is placed so that it thumps the ground at every turn of the windmill.

A noisy radio playing beat music is said to keep away baboons and other animals from cropland.

Birds can be deterred by putting a few dry beans or maize seeds into paper bags and tying the bags to a string line so that they rattle in the wind.

Frequency
Loud continuous banging is the most effective. Birds soon get used to infrequent bangs especially if the interval between bangs is regular; however, consider your neighbours!

Warning
Constant exposure to loud noises can impair hearing and upset the nerves; however, in pest control, noise is unlikely to be used with sufficient volume and frequency to be a danger.

A21: OIL

Materials
Light grade water-mixable mineral (petroleum) oil or vegetable cooking oil.

Targets
Aphid, caterpillars, fleas, flies, insect eggs and larvae, mites, mosquitoes, red spider mite, scale, thrips and whitefly; viruses (mineral oil from paraffins) and fungal diseases (rape seed oil).

Method

i Spray with a mix of 1 litre of ordinary vegetable cooking oil with 100g of bar soap (or 100ml of liquid soap) and 15 litres of water. Stir thoroughly to give a cloudy emulsion — see *warning* below. Light grade water-mixable mineral oil can be used as an alternative at 30ml of oil to 1 litre of water.

ii Spray on vegetable or light mineral oils undiluted — see *warning* below.

iii Spray with a solution of sufficient fatty soap made from vegetable oil to give a frothy

surface to the water.

iv Brush 2ml of mineral or vegetable oil on to the end of the maize silk after it has wilted but before it has begun to dry off in order to protect the cob from insect attack.

v Citrus oil is said to repel fleas, flies, mosquitoes and ticks.

Frequency
Apply as infrequently as possible. The treatment is very effective.

Warning
Take care to avoid beneficial predators. Do not spray vegetable oil (either diluted or undiluted) onto leaves unless you have first tested the reaction. Some shiny leaves like mango and sisal are not affected whereas many others are destroyed by the oil. Avoid spraying on hot days or even shiny leaves may be scorched. Spray deciduous fruit trees only in winter when they are dormant. Light grade mineral oils do not appear to harm plant leaves when the oils have a paraffin base.

A22: POTASSIUM PERMANGANATE

Materials
Potassium permanganate and water.

Targets
Aphids, armyworm, caterpillars, diamond-back moth, spider mites, whitefly, botrytis and mildews.

Method
Dissolve 30g of potassium permanganate in 9 litres of water and apply as a spray. The effects last for only 24 hours but the spray feeds the soil with potassium.

Potassium permanganate dusted on to plants is said to control mildew and botrytis.

Frequency
Several applications may be necessary for maximum effect.

Warning
Avoid predators. Do not use regularly or in large quantities otherwise the soil and plants will suffer from manganese toxicity.

A23: SALT PREPARATIONS

Materials
Salt, vinegar, water and soap.

Targets
Aphids, cabbage worm, caterpillars, slugs, snails and whitefly.

Method
i Spray aphid and whitefly with a mixture of 1 teaspoonful (5ml) of salt to 1 tablespoonful (20ml) of vinegar and mix with 1 litre of water. Dissolve half a teaspoon (2.5ml) of liquid soap.

ii The above mixture without vinegar has been recommended for use on aphids, cabbage worm and caterpillars; and as a general repellant.

iii Sprinkle a few grains of dry salt on slugs and snails.

Frequency
Apply the salt and vinegar spray twice at 5–7 day intervals. Apply sprinkled salt as often as necessary to keep snail population to low numbers. At night or during damp cloudy days are the best times for hunting slugs and snails.

Warning
Do not spray the same area too frequently with salt solutions unless sufficient extra water is being applied to flush the salt out of the soil. Apply dry salt even less frequently to prevent the fertility of the soil from being damaged.

A24 : SMOKE AND SOOT

Targets
Caterpillars, cutworm, locusts, slugs, snails and termites.

Method
i Dust the soot onto vegetables to control caterpillars or spread it as a barrier on the soil around seedlings to protect them from cutworms, slugs and snails.

ii Smoke fires in the field have been used to repel swarms of locusts and other insects but have minimal effect.

iii Tobacco smoke is effective in repelling termites and other insects.

Frequency
Apply as often as necessary.

Warning
Smoke is an irritant to the eyes and lungs. People who constantly expose themselves to smoke will be more susceptible to eye and lung infections.

A25 : SOAP SOLUTIONS

Materials
Liquid soap of the kind used for washing the dishes, solid bar soap and soap powders (modern detergent soap powders are not acceptable to the Zimbabwe Organic Producers' Association). Soft soaps made from potassium compounds are preferred as they have been found to be the most effective against insects and also to add potassium to the plant through the leaves and the soil.

Targets
Aphids, armoured crickets, armyworm, caterpillars, leaf miner, mites, psyllids, white fly, small beetles, slugs, snails and thrips. Some soaps are said to be effective against certain fungi.

Method
i A spray of half a tablespoon (10ml) of liquid soap in 1 litre of water has been found effective for aphids and whitefly.

ii Stronger soap solutions are needed for stronger insects. The following mixtures have been found effective: 1 tablespoon (20ml) of soap powder to 1 litre of water and 7g of bar soap to 1 litre of water, with or without paraffin added.

iii Any soapy water left over from washing the clothes or dishes can be diluted into a suitable spray.

iv Soap is also added in small quantities to other preparations as it helps the spray to stay on the leaves and to spread out into a thin coating.

Frequency
Apply as few times as necessary to control the insects to low levels. As always, spray selectively (on the pest only) and avoid killing off the predators.

Warning
The amount of soap needed will depend upon the soap type and the users should experiment for themselves to find the correct mix. Strong soaps such as modern detergent for washing clothes can scorch plant leaves because of the caustic soda contained in them. Consistent use of these soap powders will also damage the fertility of the soil. Wherever possible use soft soap made from potash as it adds potassium to the soil. Even soft soaps can harm plant leaves, however, if applied too frequently or if the mixture is too strong. Young and fleshy leaves (not smooth and waxy) are the most vulnerable.

A26 : SOIL

Materials
Ordinary topsoil but not pure sand.

Targets
Maize stalk borer and larvae of fruit fly and cankerworm moths.

Method
i To control maize stalk borer, pick up just enough dry soil from the ground next to the plant to block the central funnel of the plant. The soil firmly blocks the funnel when it rains and dries into a hard block during dry spells. In both cases the borers are smothered. Also, eggs are laid on the upper leaves of the maize plants. Borers can be prevented from crawling down these leaves and penetrating the stem by filling the 'v' made where the main upper leaves meet the stem with soil.

ii Disturb the soil under fruit trees to enable poultry and birds to pick up the larvae of fruit flies and cankerworm moths.

Frequency
Where high infestations of stalk borer are the rule, use the method as a preventative by applying when the maize is very small and repeat later on any plants showing signs of leaf damage. When borer infestations are not common, apply as early as possible but to damaged plants only.

Warning
Do not use pure sand for controlling stalk borer as the

caterpillars can force their way through the voids between the sand particles and will not be smothered. Sand has been proven completely ineffective.

A27 : SUGAR

Targets
Nematodes.

Method
Dissolve 2kg of sugar in a bucket of water and pour out over the soil to dehydrate nematodes. The treatment will kill all nematodes within 24 hours. The sugar should be flushed out of the soil with plenty of extra water after 24 hours. This treatment is not economically practical for large areas.

Soaking seed potatoes in sugar water for 24 hours prior to planting has been used to remove nematodes.

Frequency
This treatment should be carried out as infrequently as possible, and applied only once on any soil infested through past poor treatment.

Warning
Many nematodes are beneficial to the soil and keep each other in balance. Also, other useful soil organisms will be killed off by this treatment.

A28: SULPHUR

Targets
Spider mites, scale, fungi: especially botrytis, powdery mildew, and rust on beans and asparagus.

Method
Dust flowers of sulphur on infected parts of plants. Lime sulphur is sold commercially and consists of 1 part sulphur to 3 parts lime dissolved in water. It is used primarily to control scale in orchards. Sulphur is sometimes added to Bordeaux mixture when used for orchards.

Frequency
Use rarely and only as a last resort.

Warning
Apply on cool, cloudy days. Do not use on tender leaves as the sulphur will burn the plants. Grapes, gooseberries, cucurbits, squashes and others are particularly sensitive. Sulphur kills a lot of beneficial insects and micro-organisms and increases soil acidity.

A29 : SUN

Materials
Sunshine and polythene sheeting.

Targets
Maize stalk borer, weeds and many plant diseases.

Method
i The larvae of the stalk borer hibernates during the winter in the stem of the maize plant. It can be killed off by chopping the stover into small lengths and allowing the stalks to thoroughly dry in the sun while spread out as a surface mulch in the field.

ii Plant diseases (and weed seeds) can be killed off by using the heat of the sun while benefiting useful soil micro organisms, and improving soil tilth, nutrition, aeration and water movement. Ensure that the soil surface is smooth and moist to 60cm (70% of field capacity is recommended). Polythene is then stretched firmly over the soil to exclude air spaces. The edges are dug into the soil to prevent wind from moving it. Leave in place for 4–6 weeks. This will ensure that temperatures exceeding 37°C will be reached for extended periods. The treatment is best carried out during the dry season. Black polythene sheeting 1 to 1.5mm thick can be used but clear sheeting is preferable. The sheeting will last two months even if it has no ultraviolet stabiliser in it.

Frequency
Apply treatment i once a year only but inspect the field to ensure that all the stalks have been thoroughly chopped up. Apply treatment ii during the winter on beds which have shown evidence of disease build up.

Warning
When eradicating maize stalk borer, do not leave any standing maize stems as the borer will survive in the base of the rooted stem near to the ground. Cut through the stalk at ground level, thus leaving the root system intact to improve the soil and future infiltration.

A30 : VINEGAR

Materials
Vinegar, soap, manure and water.

Targets
Aphid.

Method
Spray with a mixture of 3 tablespoons of vinegar, 3 tablespoons of liquid soap, 2 tablespoons of liquid manure and 10 litres of water to kill off aphids and boost the plant at the same time.

Frequency
Apply as often as necessary, usually 2 or 3 times at 4-day intervals.

Warning
No dangers known as the amount of acidic vinegar recommended is too small to damage either the soil or the crop.

A31 : WATER

Targets
Aphids, caterpillars, eggs and larvae, mites, termites, thrips and whitefly; fungal and bacterial diseases particularly damping off; any crawling pest in the nursery.

Method
i Wash insects off with a strong jet of water by applying the thumb over the end of the hosepipe or by a suitable size nozzle on a knapsack spray. This treatment will also deter termites by washing away their mud tunnels and increasing the soil moisture.

ii Wash insects and fungal diseases off the leaves, branches and trunks of any plants with cold water applied with a stiff brush.

iii Spray on hot water (40–50°C) over the plant and leaves to control pests. Pour boiling water over the soil surface or blow steam through the soil to control diseases, particularly damping off in nurseries.

iv Dip fruit and seeds briefly in hot water to remove bacterial and fungal diseases — see *Part IV A5* for further details.

v Stand the legs of nursery tables in water. If the legs of the tables are made of wood, first paint them with used engine oil to prevent rot. Add a little oil to the water in the tin to reduce evaporation. Five litre oil tins cut in half make excellent containers for the water.

Frequency
Several applications of i and ii will be necessary within a few days of each other.

Warning
Control the force of the waterjet in i so that the insects are washed off but no harm occurs to the plants. New shoots are particularly vulnerable to strong jets.

For spraying over plants do not have water at higher temperatures or the leaves may be burnt.

B Plant materials

GUIDELINES FOR THE USE OF BOTANICAL SPRAYS

Not all is known concerning the use of vegetation to control pests. Much has been forgotten.

Do not assume that the vegetation named will control only the insects named. Try it on others. It may have wider application than originally supposed.

The effectiveness of the various plant remedies vary from place to place, season to season, within season and according to the insect type and maturity and age of the plant. The users should carry out their own experiments to find the plants and remedy-mixes most appropriate to their field conditions.

All preparations from plant materials should be used immediately and not exposed to sunlight before use. The best time to apply those with insecticidal properties is in the late evening. They will be more effective against the pest at this time while being less of a danger to beneficial insects such as bees.

Plant leaves can be ground down quickly by rubbing them with wet sand in a bucket.

Preparation time can be greatly reduced by boiling instead of soaking. Boil until water becomes strongly coloured with the juice: 10 minutes for most plants, 30 minutes for tobacco.

There are many plants with insecticidal and repellant properties waiting to be discovered. These can be found simply by observing which plants are not attacked by any particular insect, even though nearby ones of a different type are infested. The untouched plant should be tested for insecticidal or repellancy properties.

In the following sections, the first plant name given is the botanical one (in italics for contrast) and then the name in English; names in other languages appear in an appendix at the back of the book.

B1: USEFUL COMMON CULTIVATED PLANTS

Plants grown in humus-rich soil and fed on compost are known to be the most effective in pest and disease control.

B1.1 : *ALLIUM CEPA*; ONION

Description
Perennial bulbous herb.

Action
Mildly fungicidal, insecticidal, repellant.

Targets
Aphids, cabbage butterfly, mites, scale, thrips, tomato flies, ticks and whitefly, damping off, late blight and tomato leaf spot, mice and moles.

Parts
Bulb and leaves.

Application
Recipes vary from 10–100g onion peel or leaves per litre of water; leave for 4–7 days in a covered container before spraying. Onions can be planted to repel cabbage butterfly, mice, moles and other pests.

Other uses
Food flavouring, antibiotic, antiseptic.

Warning
The juice irritates the eyes.

B1.2: *ALLIUM SATIVUM*; GARLIC

Description
Biennial or annual bulbous herb.

Action
Anti-feedant, bactericidal, fungicidal, insecticidal, nematicidal, repellant.

Targets
Ants, aphids, armyworm, beetles, birds, caterpillars, diamond-back moth, false codling moth, grubs, house flies, mice, mites, moles, mosquitoes, nematodes, peach borer, termites, ticks and animals; fungi and bacteria.

Parts
Bulbs.

Application
Different strengths are required for different pests. A common spray: crush 1 garlic bulb, add to 1 litre of water, mix in a little soap and use immediately. The bulbs can be dried, crushed and used as a dust. The dust can be made into a spray recommended for scab, mildew, bean rust and tomato blight. Garlic planted around fruit trees and other plants will repel aphids, fruit tree borers like peach borer, mice, moles and termites. A mixture made by covering 3 crushed cloves placed in a glass jar (not a tin) with liquid paraffin, soaking for 2 days, filtering and adding 10 litres of soapy water, is said to give a spray which will kill most insects. Garlic bulbs are often planted as a repellant.

Other uses
Food flavouring, antibiotic, worm remedy.

Warning
Garlic is a broad spectrum insecticide which will kill beneficial insects as well as pests. The taste remains on the sprayed or dusted plants for up to 1 month afterwards. Do not use on legumes.

B1.3: *CAMELLIA SINENSIS*; TEA

Description
Shrub cultivated commercially for tea leaves.

Action
Anti-feedant, insecticidal.

Targets
Woolly aphid, squash bug, snails and termites.

Parts
Leaves and fruit.

Application
The used leaves can be spread around plants to repel snails; the liquid (tea) when cool can be sprayed on plants; the fruit can be soaked in water and used to repel termites.

Warning
None known.

B1.4 : *CAPSICUM FRUTESCENS AND ANNUUM*; CHILLI, SWEET PEPPERS

Description
Shrubs grown for hot spicy or sweet pods to flavour foods.

Action
Repellant and insecticidal.

Targets
General insects, fungi, bacteria and viruses.

Parts
Ripe pods and seeds.

Application
Grind 2 handfuls of chillies, soak in 1 litre of water for 1 day, shake well for a few minutes, filter, add 5 litres of water and a little soap. Chilli powder can be applied around the base of plants to repel ants, cutworm, slugs, snails and a wide range of soil pests; the juice from sweet peppers will control mosaic virus and inhibit the spread of other viruses. Chillis are often planted as a repellant.

Other uses
Food flavouring, medicine, vegetable (sweet peppers).

Warning
Leaves can be burned if the mixture is too strong.

B1.5 : *CARICA PAPAYA*; PAWPAW

Description
A 2–10 m tall spindly, short-lived, soft-wooded tree cultivated for its large oval fruit.

Action
Fungicidal, nematicidal and insecticidal.

Targets
Aphids, bugs, caterpillars, cutworm, root-knot nematodes, termites; coffee rust, powdery mildew and rice brown leaf spot.

Parts
Fruit, fresh leaves and roots.

Application
Add 1kg of finely shredded leaves to 1 litre of water, shake vigorously, filter, add 4 litres of water, 2

teaspoons of paraffin and a little soap (20g or ml), spray or water into the soil for cutworm. Extract the juice from immature fruit to control termites.

Other uses
Edible fruit and young leaves; medicinal.

Warning
None known.

B1.6: *CHRYSANTHEMUM CINERARIIFOLIUM*; PYRETHRUM

Description
Perennial, daisy-like flowering plant.

Action
Broad spectrum insecticide.

Targets
Insects in general.

Parts
Flowers.

Application
Pick flowers on a hot day, dry in shade, grind into powder, dust over insect pests; pour 1 litre of boiling water over 50g pyrethrum flowers (or 20g powder), soak for several hours, add a little soap, filter and spray.

Other uses
Medicinal and ornamental.

Warning
Apply late in the evening and spray selectively to protect bees etc. Frequency of use is often restricted by organic farming organisations.

B1.7: *CROTALARIA JUNCEA*; SUNNHEMP

Description
Erect annual shrubby herb.

Action
Insecticidal, repellant and trap crop.

Targets
Insects in general, pests in stored grain, nematodes and fungi.

Parts
Whole plant.

Application
Rotate or interplant as a trap crop for nematodes and other pests; crush plant parts in water to make a spray (no details available).

Other uses
Fodder, soil improver, weed control (esp. striga), fibre, paper, sacks.

Warning
Mildly toxic to cattle under certain conditions; seed should not be stored in room where human beings are working.

B1.8: *ELEUSINE CORACANE*; FINGER MILLET

Description
Small grain crop.

Action
Insecticidal, repellant.

Targets
Insects in general especially caterpillars, cutworm, fruit fly, snails.

Parts
Residue.

Application
Use residues as mulch for soil pests; grow as a trap crop for armyworm; soak residue in water for spraying fruit fly and other insects.

Other uses
Food crop, erosion control.

Warning
None known.

B1.9: *EUCALYPTUS SPP*; GUM TREE

Description
Fast-growing, evergreen tree.

Action
Repellant, mildly insecticidal.

Targets
Insects in general.

Parts
Young leaves.

Application
Dry and grind into a powder for dusting; crush fresh leaves in water until water is green, add a little soap, spray. The powder mixed with water has been used as a spray to repel stalk borer moths at times when the moths are active.

Other uses
Timber, oils.

Warning
Heavy water user—do not plant near water or in wet areas. Do not plant too large an area in one location.

B1.10 : *GLYCINE MAX*; SOYABEAN

Description
Widely cultivated field grain crop.

Action
Insecticidal.

Targets
Ants, woolly aphids and codling moth.

Parts
Stems.

Application
Spray prepared by soaking stems in water.

Other uses
Beans, oil, soil improver.

Warning
None known.

B1.11: *IMPOMOEA BATATAS*; SWEET POTATO

Description
Perennial with trailing ground stems and edible root tuber.

Action
Fungicidal, small inert insects.

Targets
Aphids; rice brown leaf spot, rice blast fungus; potential to control other fungi.

Parts
Leaves.

Application
Crush and soak in water, spray; heavily starched water after cooking potatoes should be tried on small immobile insects such as aphid.

Other uses
Food.

Warning
None known.

B1.12 : *LYCOPERSICON ESCULENTUM*; TOMATO

Description
Perennial soft herb, usually grown as an annual for the fruit; strong scent when leaves crushed.

Action
Insecticidal, repellant, attractant, anti-feedant, prevents egg laying, bactericidal, fungicidal.

Targets
Aphids, ants, asparagus beetle, cabbage worm, caterpillars, cockroaches, diamond-back moth, flies, grasshoppers, grubs, larvae, mites, nematodes, tomato hornworm, whitefly; fungi in general and bacterial wilt.

Parts
Any part of the plant including roots and fruit.

Application
Simmer 1kg of chopped leaves in 2 litres of water; shred 2 handfuls of leaves/stems/fruit in 2 litres of water so that the green juice is extracted, leave for 5 hours, filter, add a little soap; spray every 2 days when the butterflies of the cabbage worm are flying. Fresh plant parts are best but should be used immediately. Dried parts can be crushed into a powder and mixed with water to give a spray or applied as a dust but it is not as effective as the fresh material. Tomatoes planted around other plants will protect those plants from asparagus beetles; and the whole plant hung up in orchards or in houses is said to protect the fruit trees from many insects and the houses from cockroaches.

Other uses
Edible fruits, oil from seeds.

Warning
The leaves are poisonous to humans.

B1.13: *MANIHOT ESCULENTA*; CASSAVA (SEE WARNING)

Description
Short-lived shrub with starch-rich tuber.

Action
Nematicidal.

Targets
Nematodes; small inert insects.

Parts
Roots.

Application
Obtain juice by crushing roots, dilute 1:1 with water, spray immediately using 4 litres diluted extract per square metre; said to be very effective. Wait 20 days before sowing; use cassava peelings as a mulch against nematodes; try starchy extract after boiling and cooling cassava on aphids etc.

Other uses
Roots of bitter varieties are edible when the prussic acid has been removed by boiling; fodder, paper making, textiles, cosmetics, adhesives, flour.

Warning
Roots of bitter varieties contain prussic acid which must be removed before the root is edible.

B1.14: *MATRICARIA EXIMIA*; FEVERFEW

Description
Perennial, shrubby herb with small daisy-like flowers, natural (wild) and cultivated.

Action
Insecticidal (pyrethrin), nematicidal.

Targets
Caterpillars, flies and soft-bodied insects.

Parts
Flowers (especially), leaves.

Application
Cover 100g of leaves and flowers with 1 litre of boiling water, soak for 12–24 hours, filter, dilute with 1 litre of water, add a little soap, spray.

Other uses
Food flavouring, medicinal, perfume.

Warning
Spot spray to avoid killing beneficial insects; use immediately.

B1.15 : *MELIA AZEDARACH*; SYRINGA (PERSIAN LILAC)

Description
Fast-growing ornamental exotic deciduous tree now naturalised.

Action
Anti-feedant, contact poison, fungicidal, growth inhibitor, nematicide, insecticidal, repellant.

Targets
Wide range of insects including: ants, aphid, armyworm, beetles, bollworms, bugs, cabbage root fly, caterpillars, hoppers, grubs, moles, nematodes, stemborers, weevils, red spider mite, termites and fungi.

Parts
Bark, branches, leaves, fruit, oil.

Application
Soak 150g of fresh (50g dried) leaves in 1 litre cold water for 24 hours, filter, spray; for termites mulch with leaves and berries or dig them into planting holes; dry and grind plant parts for dusting powder. A handful of leaves and berries boiled in 5 litres of water is said to make a general fungicide and insecticide. The mixture will repel moles if made even stronger.

Other uses
Medicinal, fodder, timber, fuel, ornamental.

Warning
Effectiveness of the plant has not been tested sufficiently locally; fruit is poisonous.

B1.16: *NERIUM INDICUM*; OLEANDER (SEE WARNING)

Description
An ornamental evergreen shrub of gardens.

Action
Anti-feedant, fungicidal, nematicidal, insecticidal, rodenticidal.

Targets
Ants, flies, beetles, diamond-back moth, rodents, weevils, rice brown leaf spot.

Parts
Whole plant.

Application
Cut and soak leaves, bark and flowers in water for 30 minutes, spray; dry and grind plant parts into a dusting powder.

Other uses
Medicinal, perfumery, incense, nectar, ornamental.

Warning
The whole plant is poisonous.

B1.17: *NICOTIANA TABACUM*; TOBACCO (SEE WARNING)

Description
Erect annual herb; important cash crop.

Action
Contact and stomach poison, fungicidal, insecticidal, molluscicidal, repellant, viricidal.

Targets
Broad spectrum insecticide including: aphids, bilharzia snails, fleas, flea beetles, lawn caterpillar, leaf curl, leaf miner, scale, slugs, snails, termites, thrips, ticks, whitefly and many others; rusts, viruses.

Parts
Whole plant.

Application
Soak 1kg of bruised leaves in 15 litres of water for 24 hours, add a little soap, filter, use as a general spray; dry and grind very finely into a powder for dusting onto aphids, spider mites, slugs, snails, thrips, and various caterpillars; dust on trees and crops to repel insects and to control leaf curl virus; mulch with scrap leaves to kill slugs and snails, pupae, larvae or any adults hiding in the soil or in other mulch material and to repel aphids, flea beetles and thrips.

Other uses
Cash crop, medicinal.

Warning
Nicotene is a strong poison, avoid contact with the liquid forms; wear protective clothing if spraying otherwise use a watering can; liquids damage plants if used in higher concentrations than recommended. Do not spray or dust on leaves of the Solanaceae family — tomatoes, potatoes, brinjals and peppers. Do not use tobacco in any form on roses or they will turn black. Liquid sprays made from tobacco are not acceptable to The Zimbabwe Organic Producers' Association (ZOPA) and use of powdered material is restricted by some organic farming organisations.

B1.18: *OCIMUM BASILICUM*; SWEET BASIL

Description
Cultivated, aromatic herb.

Action
Mildly fungicidal, insecticidal, repellant.

Targets
Wide range of insects, fungi in general.

Parts
Whole plant.

Application
Soak crushed leaves in water for 24 hours, filter, spray; dry out of sun and grind as a dusting powder.

Other uses
Food flavouring, medicinal, repels mosquitoes and ticks.

Warning
The effectiveness seems to vary greatly with variety and other factors.

B1.19: *RHEUM SPP*; RHUBARB (SEE WARNING)

Description:
Perennial, large-leafed herb.

Action
Fungicidal, insecticidal.

Targets
Ants, aphids, whitefly, small caterpillars, maggots and other soft-bodied insects; club root and mildew.

Parts
Whole plant.

Application
Soak 100g fresh leaves in 1 litre of water for 24 hours, add a little soap, spray; up to 5 large leaves in 0.5 litres of water have been used to give stronger sprays; stems dug into the soil next to cabbages prevents club root.

Other uses
Medicinal, stems edible.

Warning
Leaves are extremely poisonous.

B1.20: *TAGETES ERECTA*; AFRICAN MARIGOLD

Description
Annual, erect, cultivated herb.

Action
Bactericidal, contact poison, fungicidal, insecticidal, nematicidal, repellant.

Targets
Wide range of insects including ants, beetles, nematodes and fungi; late blight.

Parts
Whole plant.

Application
Crush 100–200g of leaves, roots, flowers, pour on 1 litre boiling water, soak for 24 hours, add 1 litre of cold water, spray on plants or into soil; grow in rotation for nematodes; plant as an intercrop to repel beetles.

Other uses
Ornamental, erosion control, medicinal, food and cloth dye.

Warning
None known.

B2: USEFUL WILD PLANTS AND TREES

Among the following useful plants, the trees can be planted around homes, at the edges of gardens and fields, and on the contour ridges. Not only will they provide a ready supply of materials for pest and disease control but act as windbreaks and encourage predators to do most of the pest-control work.

B2.1: *AGAVE AMERICANA*; AMERICAN ALOE AND OTHER *AGAVE SPP.*

Description
Stout, succulent plant growing to 7 metres.

Action
Repellant and insecticidal.

Targets
Pests in stored grain and termites; buck; worth trying on other field pests.

Parts
Any part of the plant.

Application
Crush plant parts in water as field spray, 1 part plant to 5 parts water or less; dry and grind materials for dusting; cut up leaves, boil, cool and spray over plants to repel buck.

Other uses
Planted as a fence, edible buds and flowers, fibre, alcohol and medicine.

Warning
None known.

B2.2 : *AGERATUM CONYZOIDES*; GOAT WEED

Description
Erect, perennial or annual herb growing 1 metre high.

Action
Anti-feedant, bactericidal, insecticidal, nematicidal, and repellant.

Targets
Bacteria, cotton stainer, flies, vinegar fly, maize weevil; beetles in stored flour, groundnuts etc. and nematodes.

Parts
Any part of the plant.

Application
Dig the plant into the soil or use as mulch for nematodes; crush in water as a spray; dry and grind as a dust; can be used very dilute; effective for 2 weeks.

Other uses
Medicinal (antibiotic), weed control, ground cover in plantations.

Warning
None known.

B2.3 : *ANNONA MURICATA, RETICULATA AND SQUAMOSA*; SUGAR APPLE (SEE WARNING)

Description
Widely distributed small trees with edible fruit.

Action
Insecticidal.

Targets
General insects, nematodes, head lice.

Parts
Roots, leaves, unripe fruit, seeds and bark (*A. reticulata*).

Application
The above parts can be soaked in water for a few days and the liquid used as a spray. The seeds can be dried and crushed and dusted directly on to the insects or diluted with 20 parts of water as a spray. The power of the extract can be increased by soaking crushed seeds in a few drops of paraffin or a little petrol for a few hours. The seeds of Annona squamosa have been crushed in water as a spray for aphids and other insects.

Other uses
Edible fruit, medicine.

Warning
The powder made from the seeds of Annona squamosa is said to cause great pain if it gets into the eyes.

B2.4 : *ANNONA SENEGALENSIS*; CUSTARD APPLE

Description
Widely distributed shrub.

Action
Insecticidal.

Targets
General insects including aphids, diamond-back moth, grasshoppers and leaf hoppers.

Parts
Bark and seeds.

Application
Soak bark in water for several days and spray; crush dried seeds to produce a dusting powder; a stronger spray can be made by soaking the crushed seeds in a few drops of paraffin for a few hours before adding the water.

Other uses
Edible fruit.

Warning
None known.

B2.5: *ARGEMONE MEXICANA*; MEXICAN POPPY

Description
Tall, annual weed with red, flowering head.

Action
Bactericidal, fungicidal, insecticidal, nematicidal, repellant.

Targets
Ants, beetles, bugs, caterpillars, grubs, nematodes, termites, weevils; and fungi.

Parts
All plant parts.

Application
Plant parts can be soaked in water to make a spray or dried and ground for dusting.

Other uses
Medicinal, oil from seeds, soap.

Warning
None known.