The AGRODOK-SERIES is a series of low-priced, practical manuals on small-scale and sustainable agriculture in the tropics. AGRODOK booklets are available in English (E), French (F), Portuguese (P) and Spanish (S). Agrodok publications can be ordered from AGROMISA or CTA.

1. Pig keeping in the tropics
2. Soil fertility management
3. Preservation of fruit and vegetables
4. Small-scale chicken production
5. Fruit growing in the tropics
6. Simple construction surveying for rural applications
7. Goat keeping in the tropics
8. Preparation and use of compost
9. The home garden in the tropics
10. Cultivation of soya and other legumes
11. Erosion control in the tropics
12. Preservation of fish and meat
13. Water harvesting and soil moisture retention
14. Dairy cattle husbandry
15. Small-scale freshwater fish farming
16. Agroforestry
17. Cultivation of tomato
18. Protection of stored cereal grains and pulses
19. Propagating and planting trees
20. Back-yard rabbit keeping in the tropics
21. On-farm fish culture
22. Small-scale production of weaning foods
23. Protected cultivation
24. Urban agriculture
25. Granaries
26. Marketing for small-scale producers
27. Establishing and managing water points for village livestock
28. Identification of crop damage
29. Pesticides: compounds, use and hazards
30. Non-chemical crop protection
31. Storage of tropical agricultural products
32. Beekeeping in the tropics
33. Duck keeping in the tropics
34. Hatching eggs by hens or in an incubator
35. Donkeys for transport and tillage
36. Preparation of dairy products
37. Small-scale seed production
38. Starting a cooperative
39. Non-timber forest products
40. Small-scale mushroom cultivation
41. Small-scale mushroom cultivation – 2
42. Bee products
43. Rainwater harvesting for domestic use
44. Ethnoveterinary medicine
45. Mitigating the effects of HIV/AIDS in small-scale farming
46. Zoonoses
47. Snail farming
48. The Rural Finance Landscape

© 2007 Agromisa Foundation and CTA
Agrodok 30

Non-chemical crop protection

Piet Scheepens
Rik Hoevers
Foreword

Recommendation
Farmers often do not realize that their unsprayed fields are full of beneficial insects (parasitoids and predators) which keep pest numbers under control. However, these natural enemies are much more vulnerable to pesticides than the targeted pests. So when pesticides are used, natural enemies are killed and pests can develop unchecked. It is therefore essential to use non-chemical crop protection methods instead of pesticides. This booklet describes a number of tactics that can be used. It demonstrates how to work with nature to keep pests at tolerable levels. The booklet also draws attention to the Farmer Field Schools that have been set up world-wide. In these field schools, farmers learn to become active, self-reliant practitioners of non-chemical crop protection. This booklet, written by very experienced scientists, is highly recommended to farmers, extension officers and pest management practitioners.

Prof.Dr.Ir. Arnold van Huis, Tropical entomologist
Wageningen University

Acknowledgements
We acknowledge the following persons for their enthusiastic and fruitful contributions to discussions and for presenting cases for this booklet: Carol Waddington, Gerard Pesch, Francis Arulappan, William Barbier, Huub Stoetzer, Gerrit van der Klashorst, Joep van Lidth de Jeude, Moise Tchomguia and Roy Keijzer. We also thank Cambridge University Press for permission to reproduce figure 2 of this booklet, the Gatsby Charitable Foundation for permission to reproduce figure 11 and Dr. Aad van Ast of Wageningen University for permission to reproduce figure 23. Further thanks go to Barbera Oranje, for making most of the drawings.

Piet Scheepens and Rik Hoevers, Wageningen 2007
Contents

1 Introduction 6
  1.1 What is this booklet about? 6
  1.2 Why publish a booklet about non-chemical crop protection? 6
  1.3 Consequences of changing to non-chemical crop protection 8
  1.4 Outline of the booklet 9

2 Pests and pest management 12
  2.1 Characteristics of pests 12
  2.2 Shifting to non-chemical methods 18

3 Making a farm less attractive to pests 23
  3.1 The role of biodiversity 23
  3.2 Improving biodiversity 27

4 Insects and mites 33
  4.1 The life cycle of insects and mites 33
  4.2 Prevention of damage 35
  4.3 Control 39

5 Diseases caused by micro-organisms 43
  5.1 Air-borne diseases 43
  5.2 Prevention of air-borne diseases 45
  5.3 Soil-borne diseases 49
  5.4 Prevention of soil-borne diseases 49

6 Weeds 53
  6.1 Life cycle and effects 53
  6.2 Control 55
  6.3 Prevention 56

7 Life cycle of Striga and options for control 62
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Introduction</td>
<td>62</td>
</tr>
<tr>
<td>7.2</td>
<td>Life cycle</td>
<td>62</td>
</tr>
<tr>
<td>7.3</td>
<td>Control measures</td>
<td>64</td>
</tr>
<tr>
<td>8</td>
<td><strong>Farmer Field Schools and non-chemical crop protection</strong></td>
<td>69</td>
</tr>
<tr>
<td>8.1</td>
<td>What is a Farmer Field School (FFS)</td>
<td>69</td>
</tr>
<tr>
<td>8.2</td>
<td>How to set up and run a successful FFS</td>
<td>71</td>
</tr>
<tr>
<td>8.3</td>
<td>A typical FFS session</td>
<td>73</td>
</tr>
</tbody>
</table>

Further reading 77

Useful addresses 79

Glossary 81
1 Introduction

1.1 What is this booklet about?
As a farmer of arable crops or vegetables, you strive to achieve the highest yield and the best quality product possible. Of course you would prefer to do this with a minimum investment of energy and resources, but you are continuously bothered by all kinds of harmful organisms (pests) that threaten to reduce the quality and yield of your crops. Protecting your crops from these pests is extremely important, but it is difficult to achieve maximum results with a minimum of effort. You have to look not only at a measure’s immediate effect, but also at its long-term effect.

This booklet gives an overview of the main non-chemical measures you can take to protect your crops from pests. Most of these measures are preventive: they involve planning and farming practices that will help you to keep pest numbers down and limit the damage they do.

1.2 Why publish a booklet about non-chemical crop protection?
Non-chemical methods of crop protection have always been practised, but the introduction of chemical pesticides a few decades ago seemed to make crop protection a lot easier. As a farmer, you suddenly only needed to know which particular pests you were dealing with, which pesticides were available to control them, and how to apply these products safely. These products were so effective that it looked at first as though all pests could be eradicated in this way. In practice, however, the pests were not actually eradicated, because they came back every growing season. Many natural enemies were temporarily wiped out along with the pests, which gave the pests the opportunity to multiply even more explosively than before (see case 1 for an example).

To ensure a healthy crop, it was often necessary to spray several times per season just to control one type of pest. Eventually, some pesticides
did not even work anymore because the pests just became resistant to them. This happened first with pesticides used against insects and mites (insecticides), but eventually pesticides used to control diseases (fungicides and bactericides) and weeds (herbicides) also became ineffective. And since pests became resistant to frequently used chemicals, there was a continuous need for new chemicals, chemical compounds and mixtures.

Case 1: Killing predators of pest insects makes farmers more dependent on pesticides (see also case 7)
Brown Plant Hopper, *Nilaparvata lugens*, occurs in lowland rice in Asia. Before the introduction of insecticides it was hardly noticed in the crop because of its size of less than 3 mm. Its numbers were kept low by natural enemies, particularly the spider *Lycosa pseudoannulata*. One spider eats up to 20 Brown Plant Hoppers per day. Spraying insecticides early in the growing season kills most of the Brown Plant Hoppers, but the spiders are even more sensitive to the chemical. In the absence of its natural enemies, Brown Plant Hopper can recover and damage the crop. Since the introduction of pesticides, Brown Plant Hopper has become one of the most damaging insect pests in rice.

Some pesticides are also extremely poisonous for people (see case 2). Farmers are expected to know how to handle these chemicals safely, but in practice many accidents have occurred.

Case 2: Pesticides can threaten a farmer’s health
A questionnaire among 100 cotton farmers in Mozambique revealed that half of them had suffered from insecticide poisoning (Javid et al., 1998. Insect Science and its Application 18, 251-255.).

More than any other factor, these disadvantages of pesticides have sparked renewed interest worldwide in non-chemical methods of crop protection. Fortunately, small-scale farms in the tropics never completely abandoned the use of various non-chemical methods. Based on what we know about the biology of pests, this booklet attempts to explain:
- how these non-chemical pest management methods work and
- how various types of methods reinforce each other.
We hope this will enable you, as a farmer, to apply these methods more effectively and to use your own observations to optimise them.

### 1.3 Consequences of changing to non-chemical crop protection

It is not easy to compare the profitability of chemical and non-chemical crop protection. Especially if they look at one crop or one year, many people tend to under-estimate the costs of chemical control and over-estimate the costs (especially the labour costs) of non-chemical control. The costs of chemical control include not only the pesticides, but also equipment, protective clothing, safe storage and depreciation costs. And don’t forget the doctor’s bill if there is an accident. In remote areas the price that the crop will get on the local market may not cover the costs of the pesticides.

Chemical pesticides are often very effective against the target pests, but sometimes they do not work at all because the pest has become resistant to the pesticide or because of unfavourable weather conditions. In that case, costs have been incurred and there is no crop yield to pay for them.

Non-chemical crop protection is often less effective than chemical crop protection, but it is usually less expensive and is based on locally available inputs and interventions.

The undesired side effects of chemical pesticides make it difficult to combine them with many non-chemical methods. We present one example in case 3.

---

**Case 3: Combining chemical and non-chemical crop protection can be difficult**

The results of the same questionnaire in Mozambique (case 2) show that the majority of the farmers started spraying too early after sowing the cotton crop. They were unaware that such sprays reduce natural enemies and may not lead to increased cotton yields.
This booklet explains how to keep your crops healthy without using any chemical products, and provides you with some examples. It suggests that you only consider using chemicals if all else fails, and then always choose the chemicals that have the least toxic effects on non-target organisms.

Another booklet in the Agrodok series, *Pesticides: compounds, use and hazards* (No. 29), may be useful if you want to apply pesticides.

### 1.4 Outline of the booklet

This booklet does not give ready-to-use formulas on how to respond to pest X in crop A or to pest Y in crop B. It provides a more flexible way of thinking and working, which you can adapt to the crops you cultivate and to local conditions.

Whether a farmer applies non-chemical crop protection methods or chemical pesticides, he or she must be able to recognise the most important pests that occur on the farm. It is also important to know more about their life cycles and how they are affected by local conditions. You may find Agrodok No. 28: *Identification of crop damage* helpful in identifying organisms that cause crop damage.

Chapter 2 summarises the most important characteristics of pests and explains how you can learn to control them in a responsible way. The intention is not to eradicate pests, but to minimise their harmful effects.

Chapter 3 describes how you can organise your farming activities in such a way that pests have less chance of multiplying at an explosive rate. Many of these measures are effective for several years and help to control more than one type of pest.

Many measures to protect crops from pests are taken before or during cultivation. These measures are usually directed towards keeping down the numbers of a specific type of pest or category of pest organ-
isms. One example is the use of healthy seed to prevent a crop from becoming diseased in an early stage of growth. Another example is sowing a crop in rows so that weeds can be removed using a hand tool. Yet another example is planting a Neem tree, which keeps many pest insects at bay.

Since the effect of control measures depends to a large extent on a pest’s life cycle, we treat pest management in this booklet per category of pest organism. In Chapter 4 we will look at the life cycle, prevention and control of insects and mites; in Chapter 5 we will look at disease-causing moulds, viruses and bacteria; and in Chapter 6 we will look at weeds. Chapter 7 is devoted to the parasitic weed *Striga*.

**Strengthening knowledge in farmers’ communities**

This booklet discusses the general principles of non-chemical crop protection. To apply them effectively, you will need additional knowledge about the crops you are growing, the pests they may harbour and how they interact under local conditions. Farming communities often already have a lot of this valuable knowledge, but sometimes also have ideas and beliefs that are inaccurate or incomplete. For efficient production of healthy crops with little or no pesticide use, it is important to strengthen and upgrade the knowledge in farming communities. It is also important that farmers learn to make decisions based on this knowledge and on observing crops. Farmer Field Schools have proven to be an excellent means of applying and improving non-chemical crop protection. Successes have been reported from many parts of the world. For an example, see case 4 and figure 1.

**Case 4: Farmers in Ghana benefit from Farmer Field School**

250 farmers participated in the programme, and went on to increase their yields by an average of over 50% per hectare, raising seasonable profits by 30% and reducing pesticide use by 95%. With the increased income, they improved their housing conditions, paid school fees for their children, bought new clothes, and contributed to their churches. Some farmers expanded their farm and turned it into a more business-oriented enterprise. Participants from the savannah zone were able to produce enough crops to store food throughout the lean season. Farmers from more food-secure districts could afford more meat and fish in their diet.
Farmers especially valued the improvement to their health due to reduced pesticide poisoning. Female participants who were trained as farmers or extension staff members felt they had strengthened their organisational ability, leadership skills and self-esteem. Farmers working together also pushed local authorities and agricultural district offices to put more effort into community development.

Figure 1: Participants of a Farmer Field School discussing their results

In Chapter 8 we will discuss Farmers Field Schools and how they can be used in a community to reinforce crop protection knowledge and experience.