HAITI PRODUCTIVE LAND USE SYSTEMS PROJECT

SOUTH-EAST CONSORTIUM FOR INTERNATIONAL DEVELPOMENT

AND

AUBURN UNIVERSITY

Consultancy Report: Integrated Pest Management in Vegetables Gardens in Haiti, October 1994

by
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CONSULTANCY REPORT: INTEGRATED PEST MANAGEMENT IN VEGETABLE GARDENS IN HAITI

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Introduction

1. Dr K A Jones IPM Specialist at the Natural Resources Institute was commissioned by the South-East Consortium for International Development (SECID) to advise on the Integrated Pest Management for control of insect pests in vegetable gardens in Haiti as part of the US A.I.D.-funded Haiti Productive Land Use Systems (PLUS) Project.

2. SECID provide technical backup to the two implementing organisations, CARE International and the Pan-American Development Foundation (PADF), who had requested advice on IPM in mixed cropping vegetable plots (Bio-intensive Gardening, 'BIG') and other annual crops, which have been established under the PLUS project.

3. Dr Jones visited Haiti between 1 June and 22 June 1994 to undertake the consultancy. The terms of reference of the consultancy were:

a. Visit each of the four PADF team areas and two of the CARE intervention areas (probably La Fond and Passe Catabois) to:

- analyse current "bio-intensive" and home garden vegetable production with regard to viability and sustainability in the light of current IPM strategies. Through observations and interviews in field visits, determine the most important pests (and, as appropriate, beneficial insect predators and parasites). This will confirm identifications already made.

- also, in PADF areas, (i) evaluate the problem of snails in the Marigot region and (ii) observe fields with hedgerows as soil conservation structures with a view to designing a simple system to monitor changes in insect problems (as it is possible changes in microclimate and continuous presence of vegetative band may have an influence on pest and predator populations).

b. Review materials prepared by CARE for training/extension in insect pest management and assist in their revision, as necessary, to optimise their utility.

c. Prepare a report presenting findings and providing recommendations for control of pest problems mentioned above.

d. Present a one day workshop on IPM in vegetable production for senior field staff. This will include discussion of questions/problems raised/identified by them during the consultant's field visits.

Methodology

4. A total of 59 vegetable gardens and plots were visited in 6 different project locations. The locations visited represented the different agro-ecological and climatic conditions in the country. The locations visited were La Font, Basinbleau and Bombardapolis, where CARE have established Bio-intensive gardens, and Cap Haitien, Palmist-a-vin and the Central Plateau region, where PADF activities are focused. A planned visit to Marigot to assess the snail problem (see paragraph 3 a) was not possible due to closure of the road following a landslide. An itinerary is presented in Appendix 1 and people met in Appendix 2.

5. Between five and twelve gardens/plots were visited in each region. In the CARE only bio-intensive gardens were visited. In the PADF areas a wide variety of plots were visited, including bio-intensive gardens and monocropped areas planted to plantain, groundnuts and beans. Farmers and local CARE and PADF agronomists were interviewed at each site to establish the impact of pests. Observations on current pest attack were also made.

6. Although the consultancy terms of reference was to assess the impact of insect pests on vegetable plots and to advise on the integrated management of insect pests, in order to determine the importance of insect pests as a constraint to production it was also necessary to determine the importance of diseases, nematodes and weeds. Where possible this was done and recommendation for control of non-insect pests, as part of an IPM system, are also give where appropriate.

Results

7. Descriptions of the gardens and plots, which includes my own and farmers assessment of pest problems are given in Appendix 3. A total of 32 gardens/plots were visited in the CARE intervention areas and 27 in the PADF areas.

8. My own observations, as well as the responses from farmers and project staff confirmed that insect pests were considered to be the major problem in all areas. The main crops affected were cabbage, *Amaranthus* spp., plantain and maize. Panama disease in plantain, and localised problems of tomato disease and golden mosaic virus infecting beans were also causing significant losses. Whitegrub attack on yam and sweet potato was also a problem.

9. Table 1 lists the pests that were observed and identified and the crops affected. The table also gives an assessment of the importance of the pest, which regions it is found and whether control interventions are likely to be necessary. Further consideration is given to the most important pests below; for convenience these have been classified under the host plant on which they are normally found. A pest may, of course be found on more than one host plant, however, in most cases the control measures will be the same regardless of host plant, moreover some control measures are often applicable for several different pests (e.g. application of neem)

Table 1: Pests observed in farmers' plots in Haiti and their importance

Pest	Crop	Region	Importance	Pest control
Insects				
Aphids, *Aphis* spp.	Okra	La Fond	x	no
	Cabbage	La Fond	x	no
	Eggplant	Bombardopolis	x	no
Aphids, *Aphis craccivora*	Cowpea/Beans	Cap Haitien	xx	yes
		Pamist-a-vin	xx	yes
		Coupe George	xx	yes
		Central Plateau	xx	yes
Aphids, *Lysiphlebus* spp.	Cabbage	Bombardopolis	x	no
Aphids, *Rhopalsiphum maidis*	Cabbage	Bombardopolis	x	no
Beet Leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.	La Fond	xxx	yes
		Bombardopolis	xxx	yes
		Pamist-a-vin	xx	yes
		Central Plateau	xx	yes
	Swiss chard	Bombardopolis	x	no
Beetles, *Cerotoma & Diabrotica* spp.	Beans	Cap Haitien	xx	yes
		Central Plateau	x	no
Cabbage budworm, *Hellula phidilealis*	Cabbage	Bombardopolis	x	no
Cabbage looper, *Trichoplusia ni*	Cabbage	La Fond	xxx	yes
		Bombardopolis	xx	yes
Cassava hornworm, *Errynis ello*	Cassava	La Fond	x	no

Table 1: Pests observed in farmers' plots in Haiti and their importance

Pest	Crop	Region	Importance	Pest control
Insects				
Diamondback moth, *Plutella xylostella*	Cabbage	La Fond	xxx	yes
		Bombardopolis	xxx	yes
		Cap Haitien	xxx	yes
		Palmist-a-vin	xx	yes
Elateridae spp.	*Amaranthus* spp.	La Fond	x	no
	Swiss chard	La Fond	x	no
Fall armyworm, *Spodoptera frugiperda*	Maize	La Fond	xx	yes
		Cap Haitien	xxx	yes
		Central Plateau	xxx	yes
		Coupe George	xxx	yes
	Cabbage	La Fond	xx	yes
Gulf white cabbageworm, *Ascia monuste*	Cabbage	La Fond	xx	yes
		Bombardopolis	xxx	yes
Leaf miner	Lima bean	Bombardopolis	x	no
Papaya fruit fly, *Toxotrypana curvicauda*	Papaya	La Fond	xx	yes
Spodoptera spp.	*Amaranthus* spp.	La Fond	xx	yes
	Cabbage	La Fond	xx	yes
		Bombardopolis	xx	yes
		Cap Haitien	x	no
	Beet	La Fond	x	no
	Okra	La Fond	x	no
	Swiss chard	La Fond	x	no
		Bombardopolis	x	no
	Plaintain	Central Plateau	x	no

Table 1: Pests observed in farmers' plots in Haiti and their importance

Pest	Crop	Region	Importance	Pest control
Insects				
Stem borer	*Amaranthus* spp.	La Fond	x	no
Stinkbug, *Eushitus bifibulus*	Beans	Central Plateau	xx	yes
Tobacco hornworm, *Manduca sexta*	Tomato	La Fond	x	no
		Bombardopolis	x	no
	Cabbage	La Fond	x	no
	?	Coupe George	x	no
Tobacco leaf folder, *Pilemia periusalis*	Egg plant	Bombardopolis	x	no
	Tomato	Cap Haitien	x	no
Whitefly	Cabbage	La Fond	x	no
	Lima bean	Bombardopolis	x	no
	Beans	Cap Haitien	xxx	yes
Whitegrub	Plantain	Cap Haitien	xx	yes
Diseases				
Black leaf spot, *Alternaria brassicicola*	Swiss chard	La Fond	xx	no
		Bombardopolis	xx	no
Brown spot	Lima bean	Bombardopolis	x	no
Cercospora spp.	Okra	La Fond	x	no
	Swiss chard	Bombardopolis	x	no
	Beans	Central Plateau	x	no

Table 1: Pests observed in farmers' plots in Haiti and their importance

Pest	Crop	Region	Importance	Pest control
Diseases				
Fusarium wilt	Tomato	La Fond	x	no
Golden mosaic virus	Beans	Cap Haitien	xxx	yes
		Central Plateau	xxx	yes
Head rot	Cabbage	La Fond	x	no
		Bombardopolis	x	no
Leaf spot, *Cercospora personata*	Groundnut	Cap Haitien	xx	no
Leaf yellowing	Tomato	Bombardopolis	x	no
Panama disease (*Fusarium oxysporium*)	Plantain	Cap Haitien	xxx	yes
Sigatoka (*Mycosphaerella musicola*)	Plantain	Cap Haitien	xx	no
Southern blight, *Sclerotium rolfsii* (?)	Tomato	Cap Haitien	xx	yes
Weeds*				
Itch grass, *Rottboellia cochinchinensis*	-	Central Plateau	x	no
Other				
Snail	Lima bean	La Fond	x(x)	(yes)
	Cabbage	La Fond	x(x)	(yes)
		Bombardopolis	x(x)	(yes)

*Weeds are controlled by manual weeding, in the absence of weeding a range of species would be important
Brackets indicate that at certain times of year these may be important pests

Cabbage

10. Insect damage to cabbage was extensive in many of the gardens visited and represented the most significant problem in the CARE areas. Analysis of the damage estimates for cabbage in the gardens visited in the CARE area indicated that the average level of losses amounted to approx. 25% (range of 0 - 100%), moreover, the damage caused made the heads unsaleable in the market. There was some difference in the level of damage between the three regions (Table 2).

Table 2: Average damage to cabbage in the CARE intervention areas

Area	**Mean leaf damage (%)**
Bassinbleau	25.4
La Fond	15.0
Bombardopolis	33.9
All areas	26.4

11. Lea (1994, SECID unpublished results) gives a figure of approx. 54 as the number of cabbages in an average garden, and cabbage from a typical garden produced an income 256 Gourdes (1 Gourde = US$0.08approx., Info-PLUS 1, 3). In pure monetary terms losses from cabbage attack are likely to be at least 77 Gourdes, and because severely damaged cabbages are not sold could be as high as 256 Gourdes per crop; losses to cabbage eaten by the farmer's household are not taken into account. In terms of yield loss a figure equivalent to approx. 16 cabbages per season is due to insect attack.

12. The main pest species attacking the cabbage are Lepidoptera species (butterflies and moths), which eat the cabbage leaves in the larval (caterpillar) stage. The most important of these are the diamondback moth, *Plutella xylostella*, a cabbageworm (most probably the Gulf white cabbageworm, *Ascia monuste*) and the cabbage looper, *Trichoplusia ni*. Some damage was also being caused by *Spodoptera* spp. and the cabbage budworm, *Hellula phidilealis* but the level of attack by these insects was much lower. Descriptions of these pests can be found in 'The Invertebrate Pests of Annual Food Crops in Central America' by A.B.S. King and J.L. Saunders, published by the Overseas Development Administration, London and a summary is included in the updated version of an IPM training manual prepared by Matt Anderson, CARE which is presented in Appendix 4.

Amaranthus spp.

13. *Amaranthus* spp. (spinach) was grown in the majority of the bio-intensive garden. The major pest problem was leaf-roller attack (*Herpetogramma bipunctalis*). In two of the CARE areas most of the plants grown showed signs of leaf-roller attack. The average amount of damage amounted to approximately 10% loss of leaves, although in some plots more than 50% of leaves were damaged.

14. It is interesting to note that at Bombardopolis a variety referred to as exotic (the normal variety being called a local one) was not significantly attacked by leafroller, even when the local variety grown alongside was infested with leafrollers.

15. Stem borers which were present in some plots are not considered to cause major yield losses.

Maize

16. Maize was grown under an intercropping regime in several of the plots visited at the PADF sites, maize also was grown as a monocrop in some of the areas that surrounded the bio-intensive gardens visited. This crop is considered to be an important source of food and income to several of the farmers visited.

17. Damage to leaves and whorls consistent with that caused by the fall armyworm, *Spodoptera frugiperda*, was present on approximately 50% of all plants inspected. In some areas all plants appeared to be affected. The presence of *S. frugiperda*, was confirmed in the leaf whorl of some plants.

Beans

18. Golden mosaic virus affected all bean plots visited at Palmist-a-vin, resulting in total yield loss in some cases. Few whitefly were found in affected plots.

19. Several plots in Palmist-a-vin were observed to be severely damaged by leaf eating beetles, *Diabrotica* and *Cerotoma* spp.

Cowpea

20. Aphids (*Aphis craccivora*) were found on cowpea in the Central Plateau area. The infestations observed were not high, but local agronomists and farmers said that severe infestations were common during periods of drought. This aphid is known to be able to spread virus diseases.

Plantain

21. Disease of plantain (believed mainly to be Panama disease, but at least one farmer described symptoms more like Moko disease) caused severe losses to Plantain, all areas visited were affected.

22. Weevil damage (whitegrubs, *Cosmopolites sordidus*, burrowing into roots) was also a serious problem in all areas visited.

Tomato

23. At Palmist-a-vin two plots were visited in which all the tomato plants had died, it is assumed that the cause of this was a disease, but this will require confirmation. This problem was not observed at any of the other sites visited.

Sweet potato and yam

24. Whitegrub attack to sweet potato and yam was said by local agronomists to be a serious problem. Description of the former fit that of the sweet potato weevil, *Rhyssomatus subcostatus*.

Seedlings

25. Several farmers reported that seedlings were cut at soil level. This was attributed to attack by crickets (*Acheta* spp.) and noctuid caterpillars, as well as slugs and snails.

Current control methods

26. In the CARE intervention area most farmers applied neem to control insect pests. Most reported that control was effective, however, as outlined above insect damage to cabbage and *Amaranthus* spp. was still severe.

27. Both neem seeds and leaves were used to prepare an insecticidal solution (typically seeds were crushed and one handful was placed in a bucket of water and left overnight). The solution was applied either with a brush which was employed to flick the insecticide onto the plants, or poured on using watering can. A few farmers had access to use of a knapsack sprayer.

28. Most of these farmers also collected insects by hand. Some also used ashes or other botanical 'repellents', the efficacy of these are questionable.

29. The majority of farmers in the PADF regions did not carry out any control operations for insect pests.

30. No disease control measures were employed.

31. All plots visited were weeded manually.

32. Some farmers had used chemical insecticides which were purchased from local markets. The insecticide is sold in small amounts in unlabelled bags. Farmers guessed at application rates which had resulted in leaf burn. Application techniques were the same as used for neem.

33. Due to the current embargo, chemical pesticides, were not common in the markets. A number of farmers said that they would use pesticides if they were available and affordable.

Control recommendations

34. The level of pest attack outlined above does warrant control operations (Table 1). This is most effectively achieved through a system of Integrated Pest Management (IPM).

35. IPM is most appropriately described as 'a set of practices that maintain pest problems at a level below that which causes economically significant losses; it emphasizes minimal intervention - particularly with synthetic biocides (pesticides) - and husbandry of natural regulating mechanisms be they biological or cultural' (NRI, 1991, A synopsis of Integrated Pest Management in Developing Countries of the Tropics).

36. IPM is sometimes interpreted as meaning that no synthetic pesticides should be used. This is not the case rather it is a system that only employs pesticides if, and when, they are necessary.

37. There is, at present, no available information on economic thresholds of pest attack. IPM strategies are designed to reduce pest populations to a level where they are not causing economic losses to crops. There is a need, therefore to determine the level of pest attack, its affect on crop yields and the value of losses obtained. There is an urgent need for research in this area and it is recommended that initial studies be directed toward the pest problems identified above. On the basis of this study the need for use of control operations can be assessed. See Appendix 5 for more detail.

38. The current practices of intercropping and minimal use of insecticides have avoided many of the problems associated with indiscriminate pesticide use. This provides an ideal opportunity to develop a sustainable IPM strategy based on minimal pesticide use.

39. Current practices of hand collection of many insect pests (e.g. tobacco hornworm, removal of whitegrubs at soil preparation) should be continued and encouraged, particularly in the bio-intensive gardens where plot size makes such practices feasible. Manual weeding should continue and be encouraged to be undertaken regularly. Crop debris should be removed or burned to prevent disease carryover. Specific recommendations on IPM further control measures which can be used as part of an IPM strategy, to control the major pests listed above, are given below.

Cabbage

40. Control of caterpillar pests on cabbage can be achieved through application of neem; this, however, should be mixed with soap solution in order to improve the wetting and adhesion of the pesticide to the leaves.

41. Application of the neem needs to be improved in order to assure good control. It is recommended that knapsack sprayers could be supplied to farmers groups and training provided in their use. This will also require that the neem solution is filtered to avoid blocking spray nozzles. There is also a need to determine appropriate dose levels required for control of major pests; this should be achieved through field tests (see Appendix 5 for more detail). There is also a need to promote an efficient distribution system of neem seeds so that they are readily available in all regions.

42. However, it is a dangerous policy to rely on a single method of control and therefore alternatives should be available. The use of locally or regionally produced

microbial control agents provides a sustainable alternative. All the caterpillar pests found on cabbage are susceptible to the bacterium, *Bacillus thuringiensis*.

43. Both neem and Bt can be used in conjunction with parasitoid and predator insects. It is possible that parasitoid species could be established to reduce the total pest level. For example, a parasitoid *Diadegma* spp. which parasitizes *Plutella* has been successfully introduced and established in Honduras. It has been shown that this parasitoid can suppress *Plutella* populations to non-pest levels. Several parasitoids are known to attack *Ascia monuste* (e.g. *Lespesia archippivora*, *Phorocera parviteres*) and *Trichoplusia ni* (e.g. *Trichogramma minutum*, *Litomastrix trucatella*).

44. However, before such an approach is taken it is necessary to determine what the current impact of beneficial insects are in the region. The effect of predator insects can be assessed through placing a cage or net around plants to prevent ingress of predator insects. The impact of parasitoids can be assessed through collections of pest insects from the field and rearing them through to normal death, or death due to parasitoid emergence. (Eggs would also need to be collected to assess the impact of egg parasitoids). See Appendix 5 for more detail.

Amaranthus spp.

45. Application of neem should be extended to control the beet leafroller (King and Saunders recommend use of insecticide when 'more than one young plant in ten is attacked, or when mature plants are heavily infested'). As with cabbage improved application methodology, and research on application rates and thresholds need to be undertaken. This insect species is also susceptible to attack by the egg parasitoid, *Trichogramma minutum*.

Maize

46. *Spodoptera frugiperda* can be controlled on maize through the application of neem, as a spray when feeding on leaves, or in powder form mixed with ashes or sand which can be dropped in the whorl when the pest is feeding in this region.

47. The threshold for control measures is put by King and Saunders as 20% of whorls infested during the first 30 days of growth. Larger plants can withstand considerable damage to leaves without loss of yield, particularly if soil fertility is good. Rotation with leguminous crops is said to reduce re-infestation.

48. The possible use of insect pathogenic viruses (*Spodoptera frugiperda* nuclear polyhedrosis virus) should also be considered for control of this insect. The virus, which is highly specific, could be produced at a local level using simple technology. Research on production and use of this virus has been undertaken in Nicaragua, originally as part of a CARE-funded project. Application would be similar to that employed for neem.

49. *S. frugiperda* is also susceptible to the egg parasitoid, *Trichogramma* spp.

Beans

50. Confirmation should be made that the disease observed on beans is golden mosaic virus. The virus is transmitted by whiteflies (*Bemisia tabaci*). Control of the vector is difficult but can be achieved through application of vegetable (including neem) oils or chemical insecticides. Recent research has concentrated on use of the safe Insect Growth Regulators (IGRs), for example bruprofezin; however, these tend to be expensive. Insecticides based on insect pathogenic fungi are also being developed, but are not yet available.

51. It is suggested that the planting of virus resistant varieties should be promoted (this will require interventions to ensure efficient and controlled seed distribution). Also planting of beans during the hot, dry season, which encourages whitefly infestation, should be avoided. Weeds and volunteer beans act as hosts for the virus and should be controlled.

52. Where they are a problem leaf eating beetles can be controlled through application of neem solution

Cowpea

53. Attack by aphids (*Aphis craccivora*) on cowpea could be minimised by timing planting so that flowering does not occur during hot, dry conditions and close spacing of plants.

54. The application of neem should also be assessed (literature reports indicate that neem is effective against aphid species and that it has some systemic action). King and Saunders recommend that control measures should be initiated when more than one plant in ten is infested during dry conditions.

55 Several predator species, most notably ladybirds and lacewings feed on aphids, these species should be encouraged through non-use of broad spectrum chemical insecticides.

Plantain

56. Confirmation of the diseases affected plantain should await the report of the expert consultant being requested by SECID, who will also recommend the most appropriate control measures.

Tomato

57. Control options for the suspected tomato disease requires confirmation of the cause. It is suggested that either no tomatoes are grown at the sites visited, or that different varieties are tried.

Sweet potato and yam

58. Continued manual control of weevils should be encouraged at the time of land preparation. With regard the sweet potato weevil in particular, this is generally only a serious pest when crop practices are bad. Recommended practices are: not leaving tubers in the soil too long, removal of old tubers, crop residues and volunteer plants, weed control, crop rotation, replanting in gaps left by dead or weak plants.

59. In general, whitegrub attack can be reduced through intercropping with leguminous plants.

Seedlings

60. Attack by noctuid larvae may be minimised by planting out at full moon, when a large proportion of these insects are entering pupal stages.

61. Damage due to crickets are likely to be of less importance. Control in nursery beds may be achieved by using neem-based baits (bran or similar soaked in neem solution and scattered on the soil surface).

62. Traps consisting of a cylinder (e.g. banana pseudostem) and baited with local liquor could be used to attract slugs and snails. Once trapped the animals can be destroyed by hand. Alternatively molluscicides could be placed in the tubes. The presence of crop debris or rank weeds in a plot provides sites for slugs and snails to hide.

General

63. It is recommended that information should be available on the safe handling, use and disposal of pesticides; as well as outlining their problems and limitations. Pesticides are available in the market and normally sold in unmarked containers. As the embargo is lifted, as well as farmers incomes improve there are likely to be increased opportunities to purchase and use pesticides.

64. This can partially be avoided by demonstration that the IPM measures already undertaken, or recommended do work. Misuse of pesticides can only be avoided through education of users.

Living hedgerows

65. Farmers and agronomists were questioned on the impact of living hedgerows on pest problems. All except one said that pest problems were the same or less since the introduction of living hedgerows. This was partially attributed to general agronomic improvements related to project interventions, as well as removal of hiding sites for some pests.

66. One farmer said that disease problems were worse near living hedgerows, but no evidence of this was seen. The most widely sued hedgerow species (*Leucaena* spp.) is susceptible to several diseases, including rusts., leaf spot and anthracnose. It is

not thought that this species would act as a reservoir for major crop diseases such as mosaic virus (although a suspected 'mottle' virus disease has been noted to occur in Honduras on *L. savadorensis*). A pysllid (*Heteropsylla cubana*) and insect damage to pods and leaves has also been noted to occur on *Leuceuna* spp. in Central America, again it is not thought that this will present a threat to field crops. The prospect of that this 'aggressive' agroforestry tree species might itself present a weed problem cannot be ignored and its growth in the field should be monitored.

67. My own view is that these hedgerows provide sites suitable for the maintenance of beneficial insect populations.

68. Monitoring of pest population should be initiated, comparing closely related sites with and without hedgerows, over the next phase of the project. Insect and disease damage can be rapidly assessed across the fields visually (i.e. 90% plants infected with virus disease, 20% leaf damage due to insects), approx. 10 observation being made in a transect across the field (note being taken on proximity of hedgerows).

69. The presence of pest species in the hedgerows (as well as beneficial insects) can be determined through sweep netting of the hedgerows.

70. Both assessments should be carried out at monthly intervals throughout the year. Appendix 5 describes recommended methods in more detail.

Comments following presentation of results at an IPM workshop on 21 June

71. Local agronomists made the following comments:-

- Stem borers in *Amaranthus* spp. are a serious problem in some area and are increasing. Control can be achieved through application of neem or other suitable insecticide with translaminar or systemic action.

- Weevil damage to yams can be as high as 60% (I was assured the damage was due to whitegrubs and not wireworms, Elateridae).

- Scale attack and hornworm attack to cassava can be serious.

- The stinkbug (probably *Euschistus bifibulis*) can be an important, localised pest on cowpea and beans

- A disease that turns papaya leaves yellow was becoming a problem.

- Some information of appropriate doses for neem is available in Haiti (for example for use on tomatoes) and extensive data is available in the Dominican Republic.

Acknowledgements

I would like to thank all the people I met in Haiti who helped me with this task, they are listed in Appendix 2. I would particularly like to thank Matt and Gardy for translating for me - I apologise for my poor French!

Appendix 1: Itinerary

1 June: Flight UK to Port au Prince, via Paris and Point au Pietre

2 June: Drive to CARE intervention area at La Fond

3 June: Visit vegetable plots in Basinbleu region

4 June: Visit vegetable plots in La Fond region

5 June: Drive to CARE intervention area at Bombardopolis

6 June: Visit vegetable plots in Bombardopolis region

7 June: Drive to Port au Prince

8 June: Visit US A.I.D.

9 June: Drive to Cap Haitien

10 June: Visit farmers in Cap Haitien area.

11 June: a.m. Visit farmers in Cap Haitien area.
p.m. Drive to Port au Prince

12 June: Report writing

13 June: Report writing

14 June: Visit farmers at Palmist-a-vin

15 June: Drive to , Central Plateau

16 June: Visit PADF areas in Central Plateau

17 June: Visit PADF areas in Central Plateau
Return to Port au Prince

18 June: Report writing

19 June: Report writing

20 June: Preparation for workshop

21 June: Workshop on IPM to CARE, PADF and SECID staff

22 June: a.m. Debriefing at US A.I.D.
p.m. Flight to UK, arrive 23 June

Appendix 2: People met

SECID

Dr Frank Brockman, SECID project director
John (Dale) Lea, Agroeconomist

CARE Haiti

Greg Brady, Project Co-ordinator, CARE Plus project
Matt Anderson, Training Officer, CARE Plus Project
Regis Yves, Regional Manager, La Fond, CARE Plus project
Clavius Pierre, Assistant Regional Manager, Basin Bleau, CARE Plus project
Mildred Delphin, Assistant Regional Manager, La Fond, CARE Plus project
Judicael Gustin, Regional Manager, Bombardopolis, CARE Plus project

PADF

Bernard Laurant, Director
Gardy Fleuratin, Training Co-ordinator

Adrien Joseph, Regional manager, Palmist-a-vin
Friedrich Nicolas, Agronomist, Palmist-a-vin
Yves Gossin, Regional manager, Cap Haitien
Myrtho Jerome, Agronomist, Cap Haitien
Jonas Gue, Regional Manager, Mirebalais
Bredy Charlot, Agronomist, Mirebalais

USA.I.D.

Dr Abdul Waheb, Chief, Private Enterprise and Agricultural Development Office (PADO)
Ronnie Daniel, Deputy Chief, PADO
Lionel Poievien, Mission Environment Officer

Appendix 3: Descriptions of vegetable plots and gardens visited

CARE-PLUS project

Thirty-two bio-intensive gardens (BIGs) were visited in three of the CARE intervention areas. The gardens ranged in size from 10 - 320 m^2 and almost all were grown under an intercropping regime. Ownership included men, women and women's groups. Farmers (men and women) and local CARE staff were interviewed.

La Fond region

a. Bassinbleau

Garden 1

Location: village

Size: 320 m2

Description: Approx. ¾ of the plot was currently planted. Crops planted were: *Amaranthus* spp.., Lima bean, okra, cabbage, tomato, eggplant, Jack bean, carrot, squash, castor, water melon, pepper, Jews mallow. Crops were intermixed, with different combinations being grown throughout the plot. The produce was primarily grown for market.

Damage and Pests: Locals indicated that insect pests were the major problem. No real problem of plant diseases or nematodes stated. Weeding was carried out by hand and these were not considered to present a pest problem. Damage was noted mainly on cabbage (all plant affected, 10 - 20% loss to leaf area of mature plants mainly due to cabbage looper) and *Amaranthus* spp. (most plants affected by leafroller, 50 insects counted on six plants).

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Tobacco hornworm, *Manduca sexta*	Tomato
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Cassava hornworm, *Errynis ello*	Cassava (adjacent to garden)
Pathogens	
Fusarium wilt	Tomato

A local also stated that aphids are also a problem on cabbage in December. Stem borers in the *Amaranthus* spp. was also said to be present.

Pest control measures: Neem and available insecticides in market, mixed with water in bucket and applied when watering. Hand weeding.

Garden 2

Location: village

Size: 320 m^2

Description: Approx. 5/6 of the plot was currently planted. Crops planted were: *Amaranthus* spp.., Lima bean, okra, cabbage, tomato, Swiss chard and spurge. Crops were intermixed, with different combinations being grown throughout the plot. The produce was primarily grown for market.

Damage and Pests: Insect pests were said to be the major problem. Damage was noted mainly on *Amaranthus* spp. (most plants affected by leafroller, 18 insects counted on six plants). Stem borers were said not to be a problem.

List of pests found

Species	Crop
Insects	
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Spodoptera spp.	*Amaranthus* spp.

Pest control measures: No information.

Garden 3

Location: village

Size: 45 m2

Description: All currently cultivated. Crops planted were: *Amaranthus* spp., Lima bean, okra, cabbage, tomato, carrot, squash, beet root, Swiss chard, pepper. Crops were intermixed, with different combinations being grown throughout the plot. The produce was primarily grown for market. First year of production.

Damage and Pests: Locals indicated that insect pests were the major problem. No real problem of plant diseases or nematodes stated. Weeding was carried out manually and these were not considered to present a pest problem. Damage was noted mainly on cabbage (all plant affected, 50 - 90% loss to leaf area of mature plants mainly due to *Plutella xylostella* and *Spodoptera* spp., 109 *Plutella* and 2 *Spodoptera* found on six plants) and *Amaranthus* spp. (most plants affected by leafroller, 17 insects counted on six plants).

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Spodoptera spp.	Cabbage, Beet
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.

Pest control measures: Neem applied as spray every 3 weeks (using leaves at present as there are no seeds). Manual weeding.

Garden 4

Location: Riverside

Size: 320m^2

Description: Approx. 2/3 of the plot was currently planted, 1/3 just seeded. Crops planted were: *Amaranthus* spp., Lima bean, okra, cabbage, eggplant, carrot, water melon. Crops were intermixed, with different combinations being grown throughout the plot. The plot was owned by a woman's group (seven women) and crops were grown primarily for market.

Damage and Pests: The local CARE agronomist indicated that insect pests were the major problem, mainly to cabbage and *Amaranthus* spp. No real problem of plant diseases or nematodes. Leaf spot of Okra was also present on approx. 5% of the plants (probably caused by the fungus *Cercospora* spp.) Weeding was carried out by hand and these were not considered to present a pest problem. Damage was noted mainly on cabbage (all plant affected, 50 -70% loss to leaf area of mature plants mainly due to *Plutella* and *Spodoptera*, 23 and 2, respectively, on six plants) and *Amaranthus* spp. (most plants affected by leafroller, 74 insects, plus 2 *Spodoptera* spp. counted on six plants).

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Spodoptera spp.	Cabbage, Okra, *Amaranthus*
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Pathogens	
Cercospora spp.	Okra

Pest control measures: Plot had been treated twice with neem. Insects are also hand collected. Manual weeding.

Garden 5

Location: Riverside

Size: 260m^2

Description: All cultivated. Crops planted were: *Amaranthus* spp.., Lima bean, okra, cabbage, lalo, carrot, tomato, Swiss chard. Crops were intermixed, with different combinations being grown throughout the plot. The plot was owned by a woman's group (seven women) and crops were grown primarily for market. This plot is being cultivated for the first time this season and has not yet been weeded (this is to be organised between the owners).

Damage and Pests: The local CARE agronomist indicated that insect pests were the major problem. No real problem of plant diseases or nematodes stated. Damage was noted mainly on cabbage (all plant affected, 20 - 80% loss to leaf area of plants mainly due to *Plutella*, 30 insects counted on six plants) and *Amaranthus* spp. (all plants affected by leafroller, some plants killed, 15 insects counted on six plants). Some tomato plants were completely defoliated. but no pests were found on the plants (most likely to be due to the tobacco hornworm, *Manduca sexta*).

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Spodoptera spp.	Swiss chard
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Aphis spp.	Okra

Pest control measures: Hand collection of larvae. No weeding at present.

Garden 6

Location: outside village

Size: 66m^2

Description: All plot planted. Crops planted were: *Amaranthus* spp.., Lima bean, pepper, tomato, cabbage, tomato, eggplant (from previous season). Eggplant was not intermixed, other crops were intermixed, with different combinations being grown throughout the plot. The produce was primarily grown for market.

Damage and Pests: No significant pest problems were noted. A local said that last season aphids and whitefly were a problem and a few whitefly were noted on some cabbage plants (approx. 1 per 5cm2). No larvae were found on cabbage and the local said that there were no insect problems at present. A small infestation of leafroller was present on the *Amaranthus* spp. (2 larvae counted on six plants). Weeding was carried out manually and these were not considered to present a pest problem.

List of pests found

Species	Crop
Insects	
Whitefly	Cabbage
Diamondback moth, *Plutella xylostella* (adult)	
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.

Pest control measures: No insecticides have been used this season. Neem was applied last season (December) to control aphids and whitefly. Manual weeding.

Garden 7

Location: outside village

Size: $66m^2$

Description: Most of garden harvested. Crops planted were: *Amaranthus* spp., Lima bean, cabbage, castor, tomato, eggplant, beetroot, Swiss chard, squash. Crops were intermixed, with different combinations being grown throughout the plot. The produce was primarily grown for market.

Damage and Pests: The farmer indicated that insect pests were the major problem and stated that a small, elongated, winged green beetle was the main problem and that this ate the leaves of the crops. Caterpillars were said not to be a problem, but stem borers had been present. No real problem of plant diseases or nematodes stated. Weeding was carried out by hand and these were not considered to present a pest problem. No damage was noted to cabbage or *Amaranthus* spp. and no larvae were found on either. The farmer stated that the lack of pests was due to the current period being the 'off season' (i.e. hot). Crop planted for own use and market.

List of pests found

None

Pest control measures: Neem is applied when necessary, as is Sevin and Diazinon (the last two were said to be very effective, Diazinon is not often available). Insects are also collected by hand.

Garden 8

Location: outside village

Size: $24m^2$

Description: New plot completely planted. Crops planted were: *Amaranthus* spp., Lima bean, cabbage, tomato, Swiss chard. Crops were intermixed. The produce was primarily grown for own use.

Damage and Pests: The farmer said that he had no significant pest problems and said that this was because the current cold season is better for plants. Some caterpillars were often present. A small amount of damage was noted on cabbage (approx. 10% loss of leaf area, 2 *Plutella* counted on six plants) and *Amaranthus* spp. (less than 10% of plants damaged, 2 leafrollers on 6 plants).

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Green leafhopper	*Amaranthus* spp.
snail	Lima bean
Pathogens	
Leaf rot	Cabbage

Pest control measures: No pesticides used.

Garden 9

Location: outside village

Size: $14\ m^2$

Description: New plot, all of plot planted. Crops planted were: *Amaranthus* spp., Lima bean, cabbage, carrot, Swiss chard. Crops were intermixed with a high number of plants per unit area. The produce was primarily grown for own use and market.

Damage and Pests: The farmer indicated that pest problems were generally small, when there were problems these were said to be due to insects. There was little damage to cabbage (approx. 10% loss of leaf area, 3 *Plutella* and 1 looper counted on six plants) and no damage to *Amaranthus* spp. (no larvae found on six plants). Black leaf spot was seen on some of the Swiss chars.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Cassava hornworm, *Errynis ello*	Cassava (adjacent to garden)
Pathogens	
Black leaf spot, *Alternaria brassicicola*	Swiss chard

Pest control measures: No pesticides were being used at present. Manual weeding.

Garden 10

Location: outside village

Size: 20 m^2

Description: All plot cultivated. Crops planted were: *Amaranthus* spp., Lima bean, cabbage, lalo, carrot, Swiss chard. Crops were intermixed. The produce was primarily grown for own use and market.

Damage and Pests: The farmer indicated that insect pests on cabbage were the only problem (10 -15% loss of leaf area was noted and 2 *Plutella* were found on six plants. Less than 5% *Amaranthus* plants were damaged (1 leafroller found in six plants).

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Stem borer,	*Amaranthus* spp. (adjacent to plot)
Elateridae spp.	*Amaranthus* spp. (adjacent to plot)

Pest control measures: No pesticide applications made. Manual weeding.

b. La Fond

Garden 11

Location: Galbwa

Size: 20 m^2

Description: Old plot with most of crop harvested, some replanting starting. Crops planted were: *Amaranthus* spp.., cabbage, eggplant, carrot, castor, beetroot, almond. Crops were intermixed. The produce was primarily grown for market.

Damage and Pests: Locals indicated that insect pests on cabbage and *Amaranthus* spp. were the major problem. Loss of young beet plants due to cutting of the stem at night was also said to be a problem. No real problem of plant diseases or nematodes stated. Weeding was carried out by hand and these were not considered to present a pest problem. Approx. 10 % loss of leaf area was noted on the cabbage plants (2 *Plutella* and 11 loopers were counted on six plants). Some damage was noted to occur on most the *Amaranthus* spp. (2 leafrollers counted on six plants). No pest problems were said to occur on the okra, carrots or eggplants. Whitegrubs were said to be present but these were removed by hand at bed preparation (twice a year) after which they presented no problem.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Tobacco hornworm, *Manduca sexta*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.

Pest control measures: Neem is applied using a whisk to flick a solution on to the plants. Prior to introduction of neem larvae were removed by hand, still done for removal of whitegrubs at bed preparation. Sevin is mixed in the soil to control ants. Manual weeding.

Garden 12

Location: Galbwa

Size: 32 m^2

Description: Garden split into two halves, one half only *Amaranthus* spp. was grown the other half had crops intermixed. Crops planted were: *Amaranthus* spp., okra, eggplant, cabbage, pepper, Swiss chard. The produce was grown for market and own use.

Damage and Pests: The farmer said that insect pests on *Amaranthus* spp. (and in maize in adjacent field) were the major problem (5 leafrollers were counted on six *Amaranthus* spp.). Approximately 10% loss of cabbage leaf surface was noted (7 *Plutella* and 4 loopers, as well as one snail were counted on six plants). Aphids were also seen on a few cabbage plants; the farmer said that this was the first time that these had been found in this area. Some pepper plants had died, the farmer did not know the reason but said that the plants were still standing when they died and that their roots looked healthy. Whitegrubs were said not to be a problem. No problem of plant diseases or nematodes stated. Weeding was carried out manually and these were not considered to present a pest problem.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Aphids, *Aphis* ssp. (?)	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Other	
Snail	Cabbage

Pest control measures: Larvae are hand-picked from the plants daily. A mixture of Sevin and ashes is applied to maize to control *Spodoptera frugiperda*. Manual weeding.

Garden 13

Location: Galbwa

Size: 25 m^2

Description: The whole plot was planted with *Amaranthus* spp. with the exception of seven cabbage plants and one tomato plant. The produce was grown for market and own use.

Damage and Pests: The farmer said that insect pests on *Amaranthus* spp. were the major problem. All plants were damage to some extent with complete death of approx. 1% of the plants (21 leafrollers were counted on six plants). No problem of plant diseases or nematodes stated. Weeding was carried out manually and these were not considered to present a pest problem. Ladybugs were noted to be present in the crop.

List of pests found

Species	Crop
Insects	
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Spodoptera spp.	*Amaranthus* spp.

Pest control measures: No pest control measures used at present (farmer did use neem in previous garden). Manual weeding.

Garden 14

Location: Galbwa

Size: 40 m^2

Description: Garden with a wide variety of intermixed crops. Papaya was grown as an integral part of the garden. Crops planted were: *Amaranthus* spp., eggplant, cabbage, pepper, Swiss chard, lima bean, lalo, pigeon pea, corn, papaya. The produce was grown for market and own use.

Damage and Pests: The farmer said that insect pests (caterpillars and whitegrubs) were the major problem. Approximately 10 - 40% loss of cabbage leaf surface was noted (4 *Plutella* were counted on six plants, frass probably from loopers was also present). Damage was also noted on the *Amaranthus* spp. (4 leafrollers counted in six plants). Whitegrubs were said by the farmer to attack the eggplants and he felt there was nothing that could be done to prevent this. Some leaf holing was also noted on the eggplant. At least 50% of the corn plants showed signs of being attacked by *Spodoptera frugiperda*. All papaya fruits were said to be infested with maggots (papaya fruit fly). Diseases and nematodes were not thought to be a problems. Weeds were thought to be a problem that necessitated hand weeding.

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Papaya fruit fly, *Toxotrypana curvicauda*	Papaya
Fall armyworm, *Spodoptera frugiperda*	Maize

Pest control measures: Sevin was applied to control *Spodoptera frugiperda* (powder mixed with ashes dropped into leaf whorl). Neem was also used to control caterpillars in general. Manual weeding.

Garden 15

Location: Bernard

Size: 35 m^2

Description: Beds were being prepared with only a few peppers, cabbage and eggplant remaining. Crops normally grown are: *Amaranthus* spp., eggplant, cabbage, pepper, carrot, tomato, lima beans. The produce was grown for market and own use.

Damage and Pests: The farmer said that caterpillars on *Amaranthus* spp., cabbage and tomato were the main problems. Whitegrubs were also said to be a problem. Caterpillars were also said to eat eggplant leaves. The farmer did not know if diseases were a problem but said that pepper plants dry out and fall over dead. Carrot roots were also said to be attacked. Stem borers were said to be a problem on the *Amaranthus* spp.

List of pests found

None

Pest control measures: Whitegrubs are controlled by tillage and mixing Sevin in the soil. Neem or Sevin is used to control other caterpillar pests, application is carried out by flicking a solution onto the plants with a whisk. Even after treatment with Sevin 6 - 7% of cabbage plants are completely destroyed. Manual weeding.

Garden 16

Location: Bernard

Size: 10 m^2

Description: Small garden. Crops planted were: *Amaranthus* spp., cabbage, lima bean, Swiss chard, corn. The produce was grown for mainly for own use.

Damage and Pests: The farmer said that insect pests (Caterpillars and aphids) were the most important pests. Whitegrubs were not a problem in the vegetable plots but were in maize fields. The farmer said that there were no disease problems, however, he did note that some plants were stunted. Pest problems were said to be greater this season compared to previous seasons. Main damage was observed on cabbage (10 - 20% loss of leaf area, 7 loopers counted on six plants) and on *Amaranthus* spp. (approx. 20% of plants had some damage, 19 leafrollers were counted on six plants). Weeding was carried out by hand and these were not considered to present a pest problem.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Elateridae	Swiss chard
Aphids, *Aphis* ssp. (?)	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.

Pest control measures: Larvae are hand-picked from the plants. Manual weeding.

Garden 17

Location: Bernard

Size: 72 m^2

Description: Garden split into two areas a) 40m^2 planted to *Amaranthus* spp. only b) 32 m^2 at the end of the cropping cycle planted to cabbage, carrot, shallot, maize, lima. The produce was grown for market and poor quality produce being kept for own use. None of the produce had been of good enough quality to sell recently.

Damage and Pests: The farmer said that insect were the main problem. Approx. 10% of the *Amaranthus* plants were damaged (11 leafrollers counted on six plants). Very little damage was noted in the second area (cabbage plants at plantlet stage). The farmer said that the peppers (leaves and fruits) were attacked by a large green caterpillar (probably the tobacco hornworm, *Manduca sexta*).

List of pests found

Species	Crop
Insects	
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.

Pest control measures: Sevin was applied to control caterpillars, applications being made by hiring a local man who owned a knapsack ('pump') sprayer. The last crop was sprayed once with Sevin, the farmer thought this was too little. Manual weeding.

Garden 18

Location: Tardif

Size: 18 m^2

Description: End of cropping cycle. Few plants present. Farmer absent, but locals said that tomatoes suffered from a 'blackspot' disease, most likely to be early blight (*Alternaria solani*).

Garden 19

Location: Tardif

Size: 25 m^2

Description: Garden at end of cropping cycle and had been left unweeded. Crops still planted were: Cabbage, tomato, lima bean, eggplant. The produce was grown for market and own use.

Damage and Pests: The farmer said that the major pest problems were on tomato: small black and green caterpillars ate the fruits and leaves (it is thought that these were most likely to be *Spodoptera* spp.) and the plants suffered from 'black spot" (*Alternaria solani)*. Later the farmer stated that caterpillars on cabbage and corn presented a major problem, as did leaf roller on *Amaranthus* spp. No significant problem was said to occur with the other crops. A grassy weed covered the whole plot. Ants were said to eat young sorghum below the ground.

List of pests found

Species	Crop
Insects	
Tobacco hornworm, *Manduca sexta*	Tomato
Weeds	

Pest control measures: Larvae are hand-picked from the plants. A local has also been hired to spray Sevin (with 'pump sprayer'), hired when larvae seen in cabbage, applied Jan, Feb and March. Prior to project Sevin was applied by flicking with hands. Manual weeding is normally carried out.

Garden 20

Location: Nanpon

Size: 40 m^2

Description: End of cropping cycle. Crops planted were: *Amaranthus* spp., cabbage, lima bean, maize. squash. Owner not available.

Damage and Pests: Little damage. Cabbage had good heads with outer leaves holed.

List of pests found

None

Pest control measures: A local said that chlordane had been applied to the cabbage. No further details.

Garden 21

Location: Nanpon

Size: 20 m^2

Description: Garden had just been replanted. Crops planted were: *Amaranthus* spp., okra, cabbage, beetroot, carrots, lima bean, castor bean. The produce was grown for market and own use.

Damage and Pests: The farmer said that insect pests were the major problem this season, but there were no problems last season. Caterpillars on cabbage were a major pest (10 - 20% loss of leaf area noted, 1 leafroller, 1 *Plutella*, 1 striped cabbageworm found on six plants). Caterpillars on *Amaranthus* spp. was also said to be a problem (10 leafrollers, 2 *Spodoptera* spp. found on six plants). Beetroot and *Amaranthus* plants were said to be cut at ground level when young plants. Whitegrub was said not to be a problem.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Gulf white cabbageworm, *Ascia monuste*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Spodoptera spp.	*Amaranthus* spp.

Pest control measures: Neem has been applied (by watering can) but was thought not to be effective. Malathion and Sevin were available in the market but had not been used. Ashes were applied to corn outside the crop to control *Spodoptera frugiperda*.

Garden 22

Location: Nanpon

Size: 40 m^2

Description: Garden owned by same woman as garden 21 and was at the end of the cropping cycle. Crops planted were: *Amaranthus* spp., pepper, lima bean, castor,

Swiss chard, water melon, tomato, beetroot, pigeonpea, corn The produce was grown for market and own use.

Damage and Pests: The farmer said that there were little pest problems, in general pests were the same as for garden 21. The farmer again said that young beetroot plants were often cut at soil level. Insect pests were the major problem this season, but there were no problems last season. Approx. 50% of the *Amaranthus* plants had some damage, but the farmer said that the losses were not great (1 leafroller counted on six plants). No *Spodoptera* was found on the corn.

List of pests found

Species	Crop
Insects	
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.

Pest control measures: Neem has been applied (by watering can).

c. Bombardopolis

Garden 23

Location: Cadelon

Size: 56 m^2

Description: Established garden. Crops planted were: *Amaranthus* spp., tomato, cabbage, Swiss chard, pepper, carrot, maize, cassava, unidentified solonaceae. The farmer was not present.

Damage and Pests: Severe damage to all cabbage plants was observed (20 - 80% loss of leaf area, 32 *Plutella*, 1 looper, 1 *Spodoptera* counted on six plants). 90% of maize plants showed signs of damage by *Spodoptera frugiperda.* Some damage was noted on the Swiss chard (10 - 20% leaves damaged, mainly due to *Spodoptera* spp.). Little damage was found on the *Amaranthus* spp., which was a different ('exotic') variety to those previously seen. Some leaf rot was found on the cabbage plants (said by local agricultural engineer to affect 1 - 2% of the plants).

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Spodoptera spp.	Cabbage

Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp., Swiss chard
Spodoptera spp.	Swiss chard

Disease

Head rot	Cabbage

Pest control measures: It was thought by the local agent that insects were hand collected from the plants. Manual weeding.

Garden 24

Location: Cadelon

Size: 120 m^2

Description: Garden had recently been replanted. Crops planted were: *Amaranthus* spp., cabbage, lima bean, carrot, Swiss chard, eggplant, sweet potato. The produce was grown for market and own use.

Damage and Pests: The farmer and local agent said that insect pests were the major problem. Damage to cabbage amounted to approx. 10% loss of leaf area (12 loopers, 2 *Plutella* counted on six plants). Caterpillars were said to eat small eggplants. Caterpillars were also found on the tomato but these were picked off by hand and did not present a problem. Whitegrub was found in the surrounding sweet potato crop. Black spotting and necrosis to Swiss chard leaves was noted (possibly due to the fungus, *Cercospora* spp.), the farmer, however, thought that this problem was caused by a moth that also attacks coconut. Cabbage was affected by a disease that turns the leaf white before they fall off (probably downy mildew, *Peronospora parasitica*).

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Diseases	
Cercospora spp. (?)	Swiss chard
Weeds	

Pest control measures: Insects are mainly hand collected. Insecticide (Malathion) had been bought from the capital but this burned the plants. Ashes were placed on beds and this improved growth of the crop (probably due to potassium content). Neem has been applied (by watering can) every three days, often other plant leaves (e.g. garlic

and pepper) are added. This frequency of application was said to be difficult to maintain. White grubs were controlled in the sweet potato by adding a layer of neem leaves and *Sadrella oderata* leaves to the soil when preparing the bed. Manual weeding.

Garden 25

Location: Clenet

Size: 25 m^2

Description: Old garden at end of cropping cycle. Crops planted were: Cabbage, tomato, beetroot, carrots and Swiss chard. Grown for selling and eating.

Damage and Pests: The farmer said that insect pests were the major problem. Two sorts of caterpillar attacked the cabbage (one green, one black - looper and *Spodoptera* ?); these were not a problem in the previous season (damage: 10 - 20% loss of leaf area, 5 loopers, 2 *Plutella* counted on six plants). Aphids were also said to be a problem on the cabbage. Snails were also a problem on cabbage; the farmer said that they attack at night and nothing can be done to prevent this. Leafrollers were said to attack the beetroot, sometimes resulting in death of the small plants. Black caterpillars often burrow into the tomato fruits (*Spodoptera* ?) and large green caterpillars can strip all the leaves (*Manduca sexta* ?). Leaf rollers were also found in the Swiss chard. No problem was said to result from diseases and plant roots were said to be in good condition. Whitegrubs were not found in the garden.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	Swiss chard

Pest control measures: Neem has been applied (by watering can). Manual weeding.

Garden 26

Location: Clenet

Size: 20 m^2

Description: Well established garden. Crops planted were: Eggplant, maize, cabbage, carrot, leek. The produce was grown for market and own use.

Damage and Pests: The farmer said that insect pests were the major problem. Caterpillars on cabbage were said to be a problem that could not be solved, after hand

collection of larvae the larvae reappeared overnight (these larvae are thought to be the stripped cabbageworm, and possible *Plutella*). Small green and black larvae attacking cabbage hearts were said to be a problem (Gulf cabbage worm). Damage to cabbage plants was 10 - 100% loss of leaf area (9 stripped cabbage worm, 1 *Plutella*, 1 looper were found on six plants). Aphids were also found on the cabbage. Small beetles were said to make holes in eggplants and other plants. A black caterpillar was said to cut small beetroot plants off at soil level (probably *Agrotis* spp., but could be *Spodoptera* spp.). *Spodoptera frugiperda* was present on the maize. Whitegrubs were said to be rare and there were no disease or root problems.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Gulf white cabbageworm, *Ascia monuste*	Cabbage
Tobacco leaf folder, *Pilemia perinsalis*	Egg plant

Pest control measures: Hand picking. Do not use ashes as these were said to kill plants and neem was not available. Manual weeding.

Garden 27

Location: Desmoulins

Size: 16 m^2

Description: Established garden. Crops planted were: *Amaranthus* spp. (local and exotic variety), cabbage, Chinese cabbage, Swiss chard, carrot, lima bean, squash, pepper, tomato, leek. The produce was grown for market and own use.

Damage and Pests: The farmer said that insect pests were the major problem. Damage to cabbage amounted to 10 - 70% loss of leaf area (5 loopers, 2 *Plutella*, 4 striped cabbageworm counted on six plants). Both leafroller and stem borer was noted to occur on the *Amaranthus* spp. (mainly on the local variety, the exotic variety was generally free from attack), the farmer said, however, that losses to the crop were not great and unimportant as all of this crop was for home consumption, all farmers grew their own *Amaranthus*. Whitefly and evidence of leafminers was seen on the lima beans and leaf roller was found on the Swiss chard, neither was said to be a serious problem. The farmer said that whitegrubs were found in the plot but these did not present a problem; she also said that she had not noticed any disease or root problems.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Gulf white cabbageworm, *Ascia monuste*	Cabbage
(Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.)
Whitefly	Lima bean
Leaf miner	Lima bean

Pest control measures: Hand collection of larvae and manual weeding.

Garden 28

Location: Desmoulins

Size: 16 m^2

Description: Established garden. Crops planted were: *Amaranthus* spp. (local and exotic variety), cabbage, tomato, Swiss chard The produce was grown for market and own use.

Damage and Pests: The farmer said that insects were the main problem. Damage to cabbage amounted to 10 - 90% loss of leaf area (15 striped cabbageworm, 1 *Spodoptera*, 1 cabbage budworm counted on six plants). The farmer stated that very little insect attack occurred to the exotic variety of *Amaranthus* spp. and little problems occurred with local tomato varieties. An egg of the tobacco hornworm was found on the tomato plants, the farmer said that the insect could completely eat the leaves. Aphids were present on some eggplants. Ladybird larvae were present on this crop.

List of pests found

Species	Crop
Insects	
Gulf white cabbageworm, *Ascia monuste*	Cabbage
Spodoptera spp.	Cabbage
Cabbage budworm, *Hellula phidilealis*	Cabbage
Tobacco hornworm, *Manduca sexta*	Tomato
Aphids	Eggplant

Pest control measures: Hand collection of larvae and manual weeding.

Garden 29

Location: Rochfort

Size: 40 m^2

Description: Established garden. Crops planted were: *Amaranthus* spp. (exotic variety), cabbage, Chinese cabbage, tomato, leek, papaya, taro, lima bean, maize, Swiss chard, Chinese cabbage. The crop was produced for market and own use.

Damage and Pests: The farmer said that insect pests were the major problem. Damage to cabbage amounted to 10 - 30% loss of leaf area (13 loopers, 1 *Plutella*, 5 striped cabbageworm, 1 cabbage budworm counted on six plants). *Plutella*- type damage was noted on the Chinese cabbage. Whitegrubs were present in the beds and these were said to cause holing of roots; the insects were removed at tillage. An ant nest was present in the beds. The farmer said that local gardens had problems of spinach leaves being cut by insects (possibly *Spodoptera* spp.), as well as large holes (approx. 1 cm) being eaten in tomato fruits (probably *Spodoptera* spp.); these problems, however, *did not* occur in the farmers own garden. The farmer said that diseases sometimes were a problem - yellowing and death of cabbage leaves and one tomato plant had been pulled up because of yellowing leaves; the roots were said to have rotted. Brown spotting was present on the lima beans.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Gulf white cabbageworm, *Ascia monuste*	Cabbage
Cabbage budworm, *Hellula phidilealis*	Cabbage
Spodoptera spp.	Spinach
Reduvid	Chinese cabbage
Ants	
Diseases	
Brown spot	Lima bean
Rot	Cabbage

Pest control measures: Chemical insecticides purchased in the market had been used but these were said to burn the leaves. Neem and a neem, soap, kerosene mixture was now used, application being made by flicking a solution with a whisk; the latter mixture was said to work well. Manual weeding and hand removal of whitegrubs and some diseased plants.

Garden 30

Location: Rochfort

Size: 15 m^2

Description: Established garden. Crops planted were: *Amaranthus* spp. (local and exotic variety), cabbage, egg plant, Swiss chard, lima bean, leek, okra, papaya. The produce was grown for market and own use.

Damage and Pests: The farmer said that insect pests were the major problem. Damage to cabbage amounted to 10% loss of leaf area (3 loopers, 5 striped cabbageworm counted on six plants). The farmer said that two types of caterpillar - a white one and a black one - attacked the cabbage; this had made her harvest the plants early to prevent further losses. She also said that small white caterpillars attacked the tomato fruits. Aphids were said to be a problem on the cabbage and ants sometimes built nests at the base of okra plants resulting in severe damage. A small amount of leafroller damage was noted to be present on the *Amaranthus* spp. There was some leaf damage to the okra (most likely due the grasshopper attack) and a small amount of leafminer damage was noted on the lima bean. Necrosis and death of tomato leaves was noted to be prevalent. The farmer said that there were no weed problems and had not noticed any root problems.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Gulf white cabbageworm, *Ascia monuste*	Cabbage
Leaf miner	Lima bean
Diseases	
Leaf yellowing	Tomato

Pest control measures: The farmer had tried to buy insecticides in the market but none were available. Ashes were applied by hand and this was said to be successful. Manual weeding.

Garden 31

Location: Bombardopolis town

Size: 110 m^2

Description: Established and well kept garden. Crops planted were: *Amaranthus* spp. (local and exotic variety), cabbage, lima bean, egg plant, tomato, pepper, beetroot,

carrot, Swiss chard, okra, squash. The farmer was not present. The local agent said that this was a model garden and that the produce was mainly grown for market.

Damage and Pests: The local agronomist said that insect pests and water availability were the major problems, but snails were also problematic. Damage to cabbage amounted to 20 - 90% loss of leaf area (5 loopers, 1 *Plutella*, 3 striped cabbageworm counted on six plants, whitefly were also found on one of the plants). This season was said to be the worst for caterpillars on cabbage the problem was less in the other seasons. Leafrollers were noted to occur on the local variety of *Amaranthus* spp., but not on the exotic variety. Ants were burrowing into the stem of an egg plant, as well as a cabbage under which they had built a nest. Large snails were present on several cabbage plants. A black caterpillar, found in the ground (probably *Agrotis* spp.), was said to cut young plants . Aphids were present on some okra plants. Blackening and leaf death of Swiss chard was noted.

List of pests found

Species	Crop
Insects	
Cabbage looper, *Trichoplusia ni*	Cabbage
Diamondback moth, *Plutella xylostella*	Cabbage
Gulf white cabbageworm, *Ascia monuste*	Cabbage
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Aphids	Egg plant
Diseases	
Leaf necrosis	Swiss chard
Other	
Snails	Cabbage

Pest control measures: Hand collection of larvae and application of neem, soap, kerosene mixture; also neem, pepper, onion and garlic mixture. Application by flicking with a whisk. Snails controlled by placing tins, holed at both ends and containing local alcoholic drink, in the crop; this acted as a snail trap. Manual weeding.

Garden 32

Location: Flouxie

Size: 80 m^2

Description: Established garden. Crops planted were: *Amaranthus* spp. (local and exotic variety), cabbage, tomato, lima bean, beetroot, water melon, carrot, eggplant, castor. Farmer not present.

Damage and Pests: Some damage to cabbage (degree not estimated, 4 *Plutella* counted on six plants). Leafroller damage was noted on the *Amaranthus* spp. (mainly on the local variety, the exotic variety was generally free from attack). Some necrosis of beetroot leaves was noted.

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Gulf white cabbageworm, *Ascia monuste*	Cabbage
(Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.)
Aphids *R. maidis*	Cabbage
Aphids *Lysiphlebus* spp.	Cabbage

Pest control measures: Unknown.

PADF project area: Cap Haitien

Twenty-seven project areas were visited. Plots visited included monocultures (e.g. plantain) and mixed vegetable plots. Sizes ranged from 15 to 30,000 m^2. Farmers (men only) and local PADF agronomists were interviewed.

a. Grandriviere

Plot 1

Size: approx. 12,500 m^2

Description: Area entirely planted to mature plantain.

Damage and Pests: A disease was said to be an important problem. The farmer said that this affected some 40% of the plants. The disease caused a reddening of the vascular tissue in the stem of the plant. This is followed by yellowing and death of the leaves. The disease does not affect the fruits, but yield is reduced. The description fits that of Panama disease (caused by the soil-borne fungus *Fusarium oxysporium*); similar symptoms are caused by Moko disease (caused by the soil-borne bacteria, *Pseudomonas solanacerum*) but this disease also effects the fruits causing premature ripening of some and brown discolouration of the inside of unripe and ripe fruits. Sigatoka disease (leaf spot, caused by the airborne fungus *Mycosphaerella musicola*) was noted to affect most of the plants but the farmer said that the disease did not affect the yield and that the plants had 'adapted' to attack by the disease. Nematode attack was also said to be a problem; it is likely that this conclusion was drawn because the locals knew that nematodes could cause a problem, rather than a positive identification being made. Infestation by weevil larvae which bore into the plant roots and stems was said to affect all plants and to be the most important problem in the region.

List of pests found

Species	Crop
Diseases	
Panama disease *Fusarium oxysporium*	Plantain
Sigatoka , *Mycosphaerella musicola*	Plantain

Pest control measures: None

Plot 2

Size: 30 m^2

Description: Bio-intensive garden. Crops planted were: Cabbage, tomato, pumpkin, carrots, plantain. The main crops: cabbage, tomato and carrots were grown in separate blocks. The crops are normally grown for market, but current level of pest damage does not allow this for cabbage and tomato.

Damage and Pests: The main problem was said to be a tomato disease that had killed all the plants. The plants were completely dead but still standing. There was no sign of root damage and no discolouration inside the main stem. The plants died suddenly when fruits were just starting to set. The most likely cause of this is southern blight or sclerotium which is caused by the soil-borne fungus *Sclerotium rolfsii*, although normally one would expect the plants have wilted. Some red mite was noted to be on the small fruits remaining on the dead plants. Leafrolling caterpillars were also on some of the leaves (either the tobacco leaf folder, *Pilemia periusalis*, or the tomato leaf webber, *Pilocrocis* spp.). Damage to cabbage plants amounted to approx. 20% loss of leaf area (all plants affected, 2 *Plutella* counted on six plants). A small number of whitefly were also found. The farmer said that the current time of year (hot season) was bad for growing cabbage due to insect attack. Other significant pest problems in the area were described by the farmer and the local agronomist, these were: virus disease of beans, characterised by yellow and green mottling which eventually turns leaves almost completely yellow, this is probably the golden mosaic virus which is transmitted by whitefly. Cassava was said to be attacked by a hornworm, most likely the cassava hornworm, *Erinnys ello*, although the farmer pointed to a picture of the tobacco hornworm, *Manduca sexta*, when asked to identify the insect from photographs. Caterpillars eating maize leaves and within the whorl was also said to be a major problem (most likely, *Spodoptera frugiperda*).

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage

Tobacco leaffolder, *Pilemia perinsalis* (Tomato leaf webber, *Pilocrocis* spp.)	Tomato

Diseases

Southern blight, *Sclerotium rolfsii* (?)	Tomato

Pest control measures: Neem is applied to control caterpillars. A solution is 'watered' on the plants from a bucket and leaves are laid on the ground between the rows of plants.

Plot 3

Size: 3 - 4000 m^2

Description: Plot entirely planted to groundnuts on a steep slope.

Damage and Pests: A suspected disease was said to be the main problem, although yield losses were said to be small. The disease is characterised by wilting and death of some shoots and the roots of the plant were said to be spongy, some roots were said to be eaten. A possible cause of the shoot death is the fungus *Diplodia natalensis*. Leaf spot was also noted on some leaves, this is most likely to be caused by the fungus *Cercospora personata*. Caterpillars were said to sometimes attack the leaves of the plants, this is most likely to be the soybean looper, *Anticarsia gemmitalis*.

List of pests found

Species	Crop

Diseases

Leaf spot, *Cercospora personata*	Groundnut

Pest control measures: None

Plot 4

Size: 24 m^2

Description: Bio-intensive garden. Crops planted were: *Amaranthus* spp. , cabbage, cowpea, maize, bean. Intercropped.

Damage and Pests: A small amount of damage was noted to the cabbage (approx. 0 - 5% loss of leaf area, no insects found). Evidence of leafroller damage was also noted on the *Amaranthus* spp.

List of pests found

None

Pest control measures: Neem solution had been applied to the cabbage (6 sprays since planting in May).

Plot 5

Size: 270 m^2

Description: Home garden, half planted mainly with eggplant. Crops planted were: Eggplant, shallot, cowpea, okra.

Damage and Pests: The farmer said that ants were a major problem of eggplant, nests being made at the base of the plants and the ants burrowing into the stems. Leaf roller and shoot fly was also present on the eggplant. Small holes in several of the eggplant leaves were said by the farmer to be caused by a caterpillars, and a small, green caterpillar was said to attack eggplant seedlings, sometimes killing them. Actual losses of yield to plants was said to be small, but this was attributed to effective pest control measures (see below). The farmer also showed weevil damage to plantain which was planted adjacent to the plot. Approximately 12 holes were present in the stem and one weevil larvae was found. The farmer said all plants were affected, resulting in poor fruit production and quality; as a result he was unable to sell any of the crop.

List of pests found

Species	Crop
Insects	
Banana weevil,	Plantain

Pest control measures: Insecticide (Malathion) was applied as a powder around the stem of eggplants on the soil to control ants. Neem (solution made from leaves) was applied to the eggplant to control caterpillar pests.

b. Leblan

Plot 6

Size: 15 m^2

Description: Bio-intensive garden. 90% planted to cabbage with a few bean plants. First crop grown on plot; produce mainly for farmer's own use.

Damage and Pests: Very little damage was noted to cabbage (0 - 1% loss of leaf area, 1 *Plutella* pupa found). The farmer said that small, green caterpillars (probably *Plutella*) were a problem, as were small, black crickets (probably the field cricket, *Acheta assimilis*) which cut seedling at soil level. Yellowing of some cabbage leaves was said to be due to the sun.

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage

Pest control measures: Caterpillars were regularly hand picked from the cabbage. Manually weeded.

Plot 7

Size: 3000 m^2

Description: Plot intercropped with maize, beans and some young plantain.

Damage and Pests: Farmer said that crickets and caterpillars were main problems. He said two types of cricket were important, a black one (probably the field cricket, *Acheta assimilis*) which cuts small maize plants at ground level, and a yellow one that eats the leaves of the beans. Caterpillar attack to maize was said to be a major problem; all plants inspected were found to have whorl damage and one *Spodoptera* eggmass was found, as well as one *Spodoptera frugiperda* larva. The caterpillar problem was said to be more important than the grasshopper problem. Snails were said to be a problem on beans. A small amount of leaf disease (necrosis) was noted on the bean plants, when questioned the farmer said that diseases to beans were important but it was more important in other regions. The farmer used living hedgerows as soil conservation structures. He said that there was a reduction in pest and disease problems since the introduction of the living hedgerows and attributed this to nutrients (nitrogen etc.) being produced by the hedgerow plants which improved the vigour and growth of the crop.

List of pests found

Species	Crop
Insects	
Fall armyworm, *Spodoptera frugiperda*	Maize

Pest control measures: The farmer 'traps' insect pests by spreading kitchen oil on palm leaves which he places between plant rows. Insects get stuck to the oil. He also visits the plot at night and hand collects larvae from the plants. He said that he would use pesticide, which is available from the Ministry of Agriculture, but cannot afford to buy any. Manually weeded.

Plot 8

Size: 100 m^2

Description: Bio-intensive garden. Crops present: Cabbage, leek, tomato, eggplant, pepper. Mainly grown in separate beds (some eggplant and pepper intercropped with cabbage). Mostly cultivated for own use, excess sold at market

Damage and Pests: Farmer said that insect damage to cabbage (*Plutella*) was the main problem, particularly when the cabbage heads were being formed. Present damage ranged from 0 - 10% loss of leaf area. No larvae were found on inspection of six plants. No damage was noted to other crops. Green caterpillars were said to cut seedlings at soil level. Some weeds were present (approx. 15% coverage of soil surface).

List of pests found

None

Pest control measures: Pepper solution has been used to control caterpillars, application being made by flicking with the hands. Larvae are also collected by hand. The plot is manually weeded, but time constraints had prevented this recently.

Plot 9

Size: 2500 m^2

Description: Plot intercopped with beans and maize. Beans said by local agent to be the most important crop in the area.

Damage and Pests: Virus disease to the bean plants (yellow, light green, dark green mottling of leaves, poor yield) was prevalent and said by the farmer to be the major problem. The disease was said to be worse at rains following drought. Most likely to be golden mosaic virus. A number of beetles (probably *Cerotoma* and *Diabrotica* spp.) were found to be eating some of bean leaves. The farmer also said that caterpillars attacking maize (most likely *Spodoptera frugiperda*), as well as crickets and a 'mealy bug' (species not known) attacking beans are also significant pests. The farmer had planted living hedgerows (consisting of sugarcane and weed species); he said that there was no difference in the type or level of pest attack prior to, or since, the hedgerows had been planted.

List of pests found

Species	Crop
Insects	
Beetles, *Cerotoma* and *Diabrotica* spp.	Beans
Disease	
Golden mosaic virus	Beans

Pest control measures: The farmer had used a stakes with orange-halves attached to the top. These were to attract and trap the 'mealy bugs.' The farmer said that this technique did not work. No other control techniques were used. The farmer said that he had no access to chemical insecticides because they were too expensive. Manually weeded.

c. Plaisance

Garde Bederot

Plot 10

Size: 1600 m^2

Description: Vegetable plot. Intercropped with beans, maize, banana, cassava, yam. Smaller area also planted to cabbage and tomato.

Damage and Pests: The beans were badly affected by golden mosaic virus. The disease affected every plant; the farmer said that the disease became serious after rainfall following a period of drought. Some whitefly were found in the crop, distribution was patchy. *Spodoptera frugiperda* was noted to have attacked approx. 10% of the maize plants. Significant damage was noted on the cabbage plants (approx. 5 - 25% loss of leaf area, 5 *Plutella*, 1 *Spodoptera* counted in six plants. The farmer said that whitegrubs were a significant pest of plantain. Black Sigatoka was noted to affect most of the plantain. Disease symptoms similar to that caused by Panama disease was described (see plot 1) and this was said to cause a major yield loss in the surrounding plantain plots. The plantain varieties grown in the area were said to be two local ones: Poban and Jedinet. Fungal disease of yam was mentioned as an important local problem. Living hedgerows consisting of sugarcane, corn and pineapple were grown in the plot. The farmer said that there had been no difference in insect attack prior to and post planting of the living hedgerows. He did say, however, that there had been an increase in the incidence of the mosaic virus disease in beans, but on further questioning it was established that this increase had also occurred in plots which used traditional hedgerows of cut branches (a field of beans across the valley from this plot which was completely yellow in colour resulting from the infection had traditional hedgerows).

List of pests found

Species	Crop
Insects	
Fall armyworm, *Spodoptera frugiperda*	Maize
Whitefly, *Bemisia tabaci*	Beans
Diamondback moth, *Plutella xylostella*	Cabbage
Spodoptera spp.	Cabbage
Diseases	
Golden mosaic virus	Beans
Sigatoka	Plantain
Panama disease	Plantain

Pest control measures: None for insect or disease control. Manually weeded.

Basin

Plot 11

Size: 1600 m^2

Description: Vegetable garden. Originally completely planted to cabbage, second crop grown under intercropping. Crops planted: Beans, Plantain, cabbage, pepper, okra, pigeonpea, cowpea, maize, papaya, yam. Grown for own use and market.

Damage and Pests: Beans were showed mottling characteristic of mosaic virus (probably Golden mosaic virus); there was, however, no sign of whitefly, although the farmer said this insect did attack the crop. The beans were planted at a high density throughout the plot. Caterpillars were said to be an important pest of cabbage (present damage 10 - 25% loss of leaf area, 6 *Plutella*, 1 *Spodoptera*, 1 aphid counted on six plants), although in the previous season was cabbage was grown as a monocrop there was not a problem. The farmer also said that looper caterpillars attacked the cabbage and were a major problem. The aphid, *Aphis craccivora*, was noted to be present on approx. 1% of the cowpea plants, the farmer said this pest was common. Damage typical of *Spodoptera frugiperda* attack was found on a few maize plants, the farmer said this was due to a small white caterpillar. Grasshoppers were also said to be a problem as were slugs which eat pepper and bean plants. Whitegrubs attacking yam was said to be a significant problem. A disease of plantain was said to kill some plants, this was described as turning the inside of the stem yellow and black; the stem also smelt bad. Symptoms typical of Panama disease were also described. A number of weeds were present in the plot. The farmer had planted living hedgerows consisting of plantain, yam, pineapple, sugarcane and pigeonpea. Pest problems were less since the establishment of the living hedgerow, but the farmer attributed this to improved agronomic practices resulting from PADF activities (e.g. training in use of neem).

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Spodoptera spp.	Cabbage
Aphids, *Aphis craccivora*	Beans
Diseases	
Golden mosaic virus	Beans
Weeds	

Pest control measures: Calcium dolomite was applied to soil at planting to control weevils in yams. Fenitrothion had been applied using a whisk to control insects, but burned the plants (insecticide from the Dominican Republic was repackaged in unlabelled bags in the market, the farmer guessed the application rate of 1 teaspoon per litre. Crushed neem leaf solution was also applied with a whisk. Sometimes fires were lit at night to attract and kill flying insects (said to be grasshoppers). The plot had been weeded twice, at soil preparation and 22 days after planting, using a hoe. The farmer said he was planning to weed again and will leave the weeded material on the soil as a green manure.

PADF project area: Palmist-a-vin

Plot 12

Size: 80 m^2

Description: Vegetable garden. *Amaranthus* spp., plantain, cassava, cabbage, tomato, eggplant, beans, sugarcane. Living hedgerows (*Leucaena* spp. planted this year). Grown for own use and market.

Damage and Pests: Extensive damage to *Amaranthus* spp. (90% loss of leaves in places) caused by leafroller; also some damage characteristic of stem borer. Cabbage was also extensively damaged (20 - 50% loss of leaf area, no larva found); damage characteristic of *Plutella*, adults and pupae seen. The farmer said that during the wet season rotting of cabbage and tomato was a problem. Weeds were present in the plot covering approx. 10% of soil surface.

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage
Aphids, *Aphis craccivora*	Beans
Weeds	

Pest control measures: No control measures for insects or diseases. The plot is manually weeded.

Plot 13

Size: 80 m^2

Description: Vegetable garden. Planted to cabbage, with living hedgerows (*Leucaena* spp.). Planted for own use and market.

Damage and Pests: Damage characteristic of *Plutella* to cabbage (20 - 40% loss of leaf area). The heads were also rotted on approx. 10% of the cabbage. The farmer had not noticed any difference in pest problems since the hedgerows had been planted. Weeds were present in the plot covering approx. 25% of the soil surface.

List of pests found

Weeds

Pest control measures: The farmer has applied a soap solution (called 'safer') to control insect pests. Applications were made with a knapsack sprayer. The farmer said that this method of control was ineffective. The plot was manually weeded.

Plot 14

Size: 120 m^2

Description: Vegetable garden. Crop planted were *Amaranthus* spp., (mainly), maize, beans, pepper, tomato.

Damage and Pests: Severe damage to the *Amaranthus* spp., (approx. 90 - 100% loss of leaves) caused by leafrollers and, to a lesser extent, stem borers. The farmer said that leafroller , as well as leaf miner, were a serious problem on seedlings gown in the seed bed. A small amount of damage was noted on the maize, the farmer said that this was not a significant problem and described the pest as a white and light red/brown maggot. Weeds covered approx. 10% of the soil surface.

List of pests found

Species	Crop
Insects	
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.
Weeds	

Pest control measures: None for insects and diseases. Weeded manually (four times since beginning of season, including once at land preparation).

Plot 15

Size: ?

Description: Vegetable garden. Plot mainly planted to cabbage with a few maize plants. Grown for own use and market.

Damage and Pests: Cabbage damaged by *Plutella* (40 - 80% loss of leaf area, no larvae seen but pupae present on leaves). The farmer also said that he had stopped growing tomatoes because of the high level of insect attack; damage was said to be due to green and black bugs (possibly Membracidae such as *Antiathe expanse*). The local agronomist also said that tomato fruits turned rotten following heavy rains. He also outlined other pest problems in the area: the main one was soil insects boring holes at soil level into sweet potato (most likely the sweet potato weevil, *Rhyssomatus subcostatus*). Groundnuts are grown extensively in the region, but were said to have no significant pest problems.

List of pests found

Species	Crop
Insects	
Diamondback moth, *Plutella xylostella*	Cabbage

Pest control measures: None, except for manual weeding.

<u>PADF area: Central Plateau</u>

a. Laschotas

Plot 16

Size: 6000 m^2

Description: Plot planted mainly to maize and beans; some pumpkin and pigeonpea. Grown mainly for market. Living hedgerows planted one year ago.

Damage and Pests: The most important problem was said by the farmer to be virus on the beans (symptoms characteristic of golden mosaic virus). Insect attack on beans and pumpkin was also said to be a problem (approx. 20% loss of leaf area of beans due to insect damage), but this was not thought to significantly affect yield. The farmer said that bean yield was significantly reduced by stink bugs feeding on pods. Some whitefly were present on the beans, but the density was not high. Weed density was high, approx. 50% coverage of soil surface. No difference had so far been noted with pest problems pre- or post-planting of living hedgerows.

List of pests found

Species	Crop
Insects	
Spodoptera frugiperda	Maize
Stinkbug, *Euschitus bifibulus*	Beans
Whitefly, *Bemisia tabaci*	Beans
Diseases	
Golden mosaic virus	Beans
Weeds	

Pest control measures: None, except manual weeding (two weedings carried out this season, no further weeding will be undertaken until beans are harvested).

Plot 17

Size: 1600 m^2

Description: Planted mainly to maize with some intercropping to cowpea, pigeonpea , okra and beans. Grown for own use and market.

Damage and Pests: The farmer said that aphids (*Aphis craccivora*) were a significant pest of cowpea, causing severe yield loses. Some mosaic virus was present on the beans and a few whitefly were seen, the farmer said that these were present. Damage by leaf feeding beetles (*Cerotoma* and *Diabrotica* spp.) was also observed on the beans. *Spodoptera* spp. was said to attack okra. *Spodoptera frugiperda*-type damage was observed on approx. 10% of the maize plants. A living hedgerow (*Leucaena* and maize) had been planted this year. Whitegrubs were said to be a severe problem in the surrounding sweet potato, although the damage observed was more like that caused by the larvae of click beetles (Elateridae).

List of pests found

Species	Crop
Insects	
Beetles, *Cerotoma* and *Diabrotica* spp.	Beans
Aphids, *Aphis craccivora*	Beans
Diseases	
Golden mosaic virus	Beans
Weeds	

Pest control measures: None apart from manual weeding.

Plot 18

Size: 2000 m^2

Description: Maize, plantain, cassava, cowpea, pigeonpea.

Damage and Pests: Leaf damage (probably beetles). Aphids (*Aphis craccivora*) were also on a few bean plants. Damage characteristic of *Spodoptera frugiperda* was observed on 5% of the maize plants. Living hedgerow (*Leucaena*) had been planted this year.

List of pests found

Species	Crop
Insects	
Aphids, *Aphis craccivora*	Beans
Spodoptera spp.	Plantain

Pest control measures: None, apart from manual weeding.

Plot 19

Size: 1200 m^2

Description: Cowpea, maize, plantain, pigeonpea. Grown for own use and market.

Damage and Pests: Attack by aphids (*Aphis craccivora*) was causing severe damage. Damage characteristic of leaf feeding beetles was also present. Approx. 5% maize plants had damage characteristic of attack by *Spodoptera frugiperda*. The farmer said that disease of plantain was a severe problem; the description of the disease (reddening

of psuedostem, leaf death, premature ripening and yellowing of fruit) indicated that this was due to Moko disease (*Psuedomonas solanacearum*). Whitegrubs (banana weevil) were also said to be a problem. Weeds were present (approx. 25% soil cover), including itch grass (*Rottboellia cochinchinensis*).

List of pests found

Species	Crop
Insects	
Aphids, *Aphis craccivora*	Beans
Weeds	
Itch grass, *Rottboellia cochinchinensis*	

Pest control measures: None except for manual weeding.

Plot 20

Size: 6000 m^2

Description: Maize, pigeonpea, plantain, cassava.

Damage and Pests: Little pest problems. Some damage by *Spodoptera frugiperda* to maize (approx. 10% of plants damaged).

List of pests found

Species	Crop
Insects	
Fall armyworm, *Spodoptera frugiperda*	Maize

Pest control measures: None except for manual weeding.

Plot 21

Size: 1000 m^2

Description: Maize, okra, beans, cassava. Grown for own use and market.

Damage and Pests: The farmer said that a shootfly (possibly the cassava shootfly, *Silba* spp.) was said to be a significant problem. Damage characteristic of *Spodoptera frugiperda* was observed on 100% of maize plants. Approx. 15% weed cover. Newly planted *Leucaena* hedgerows were present in the field.

List of pests found

Weeds

Pest control measures: None apart for manual weeding.

Plot 22

Size: 3000 m^2

Description: Cassava, sesame, squash, maize, beans. Grown for own use and market.

Damage and Pests: The maize was severely attacked by *Spodoptera frugiperda* (100% of plants attacked, some completely destroyed). There was some leaf damage to beans the beans characteristic of beetle attack. The field contained living hedgerows that had been established three years ago. The farmer said that he had not noticed any difference in pest problems pre- and post-planting of the hedgerows.

List of pests found

Species	Crop
Insects	
Spodoptera frugiperda	Maize

Pest control measures: None apart from manual weeding.

Plot 23

Size: 13000 m^2

Description: Plot planted to beans and maize. Grown mainly for market.

Damage and Pests: All bean plants showed symptoms of being infected with Golden Mosaic Virus. Approx. half of the plants also were affected by a disease that resulted in necrosis of the lower leaves (possibly caused by *Circospora*). The farmer said that the mosaic disease was more important than the leaf necrosis, as mosaic infection often resulted in no yield, whereas the leaf necrosis resulted in a reduced yield. The farmer also said that slugs can be a major pest, in some years (from May to August) they can cut up to 60-70% of seedlings. Caterpillar attack on maize (*Spodoptera frugiperda*) was also said to be a problem. When vegetables are grown the farmer said that grasshoppers and caterpillars (loopers) were a problem. Debris from the previous crop (maize) was left in the field.

List of pests found

Species	Crop
Diseases	
Golden mosaic virus	Beans
Necrosis (*Cercospora*)	Beans

Pest control measures: Attempts to control slugs have been undertaken by placing papaya leaves in the crop which attract the pest, applications of salt and ash have also been made. Burning crop debris has also resulted in reduced slug populations, although this practice also is said to increase soil fertility the farmer did not like doing this. The farmer has previously used chemical insecticides (Sevin and fenitrothion) bought from the local market. The product was sold by the spoonful in unlabelled bags (1 - 2 spoonfuls added to 1 gallon of water) and applied either with a knapsack sprayer, a watering can or by flicking with a brush. Insecticide is currently not available on the market. Poison is also used to control rats in the maize (normally the poison is placed on the rock walls which have been built as soil conservation structures).

b. Coupe Gorge

Plot 24

Size: 3000 m^2

Description: Maize, small amount of yam, cassava and cowpea.

Damage and Pests: Extensive damage to maize caused by *Spodoptera frugiperda* (90% of plants affected), also some leaf damage probably caused by grasshoppers. The local agronomist said that whitegrubs can also be a serious problem in the dry season. When vegetables are grown in the region (mainly cabbage, tomato, eggplant and *Amaranthus* spp., as well as onion, carrot and beetroot) caterpillars were said to be a major problem (various kinds, but included loopers, *Spodoptera* spp. and *Plutella*). Slugs were said to be a serious pest at transplanting, often cutting all the plantlets. Crickets and grasshoppers were also said to be a problem. Aphids on cabbage and eggplant was also said to be important, aphids (*Aphis craccivora*) was also noted on the cowpea. There was approx. 10% weed cover. It was also noted that debris from the previous maize crop was left on the soil, this was said not to act as a refuge for pests such as slugs when it is 'thinly' spread over the soil.

List of pests found

Species	Crop
Insects	
Tobacco hornworm, *Manduca sexta*	-

Aphids, *Aphis craccivora* Beans

Weeds

Pest control measures: No pest control measures, beside manual weeding. Some local farmers do by chemical insecticides from the local market, mainly Sevin but this was said to be mixed with wheatflour and ash and was ineffective. Farmers wished to use chemical pesticides.

Plot 25

Size: 1500 m^2

Description: Maize, Plantain, eggplant, sorghum, pigeonpea, cowpea, sweet potato, yam.

Damage and Pests: Caterpillar (*Spodoptera frugiperda*) attack to maize was said to be the most important pest problem (50% of plants affected); the same caterpillar was said to be an important pest of seedlings, cutting them at soil level (likely to be another *Spodoptera* spp.). Both sweet potato and plantain was said to be attacked by weevils (*Cylas formicarius* and *Cosmopolites sordidus*, respectively). A small amount of leaf holing and leaf miner damage was noted on the cowpea. The farmer said that there was poor seed germination (unclear whether this was poor seed quality or pest problems such as mice).

List of pests found

Species Crop

Insects

Fall armyworm, *Spodoptera frugiperda* Maize

Pest control measures: None, apart from manual weeding.

Plot 26

Size: 3000 m^2

Description: Maize, cowpea, cassava, okra, pumpkin, pigeonpea, plantain, *Amaranthus* spp. Grown for own use and market.

Damage and Pests: *Spodoptera frugiperda* damage was evident on 30% of the maize plants. The *Amaranthus* spp. was severely damaged by leafroller (100% of plants affected). Aphids were said to be a severe problem on surrounding fruit trees, as well as attacking the *Amaranthus* spp. Whitegrub attack to plantain was also said to be a severe problem. (cassava disease). The farmer said that green bugs on bean pods and small caterpillars inside pods can be a problem. *Leucaena* hedgerows established this year.

List of pests found

Species	Crop
Insects	
Fall armyworm, Spodoptera frugiperda	Maize
Beet leafroller, *Herpetogramma bipunctalis*	*Amaranthus* spp.

Pest control measures: None apart from manual weeding.

Plot 27

Size: 13000 m^2

Description: Maize, sorghum.

Damage and Pests: Damage by *Spodoptera frugiperda* to 50% of plants. A small amount of leaf damage was also evident on the sorghum; this looked most likely due to grasshoppers. Cob damage was also found on a few maize plants, this was said to be due to a caterpillar that also attacks tomato fruits (most likely *Heliothis* spp.). Whitegrubs used to be a problem - but were not now due to improved land preparation and fertility. Mosaic affected beans when planted (September/October).

List of pests found

None

Pest control measures: None, apart from manual weeding.

Appendix 4

I. INTRODUCTION TO INTEGRATED PEST MANAGEMENT (IPM)

Integrated Pest Management is concerned with combining a number of control techniques, in a particular cropping system, for a whole range of pest species in order to provide an overall coherent strategy for pest management.

IPM is a pest management system that utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest population levels below those causing economic injury. One cannot eliminate all the harmful insects in the garden without harming the garden. IPM emphasises the maintenance of beneficial organisms, such as insect parasitoids, that can reduce pest populations. It encourages the use of control measures only when necessary; this necessitates that action thresholds are known and used, i.e. the pest population level at which crop losses will occur, the cost of which (financially or socially) are greater than the cost of carrying out control measures. IPM encourages the use of non-chemical control measures, where possible, but does not preclude the use of chemical pesticides, if necessary. When chemical pesticides are used, one should be chosen that is effective against the peat species but has low toxicity to non-target organisms. The correct and safe use of pesticides (e.g. efficient and effective application) should be emphasised.

In regards to insect pests in Bio-intensive Gardens, there are a number of potential management techniques that can be combined to avoid, limit and eradicate insect pest infestations. The management strategy combines cultural, biological, mechanical, and chemical means to limit the damage harmful insects can cause. Management of an insect pest in a crop can be achieved if the techniques used reduce both the initial numbers of pests infesting the crop and the rate of insect pest population growth. The size of the initial numbers and the rate of insect pest population growth may be reduced by agronomic practices (cultural). Pest management practices should also seek to augment the size of the natural enemy populations in the crop system (biological). Insect pest numbers in the garden can be reduced through the use of barriers, traps, or handpicking (mechanical). When the number of pests becomes such that they are causing serious economic damage to the crop, in spite of the preceding methods, then it may be necessary to utilize insecticides that can reduce the pest population to more acceptable levels (chemical) or alternatively, some naturally occurring microbes may be used as insecticides (microbial).

Farmers may have a number of potential options that can be used for the control of a particular pest. A farmer should make the selection based on the relative merits of each control measure in terms of the ability of each option to meet the farmers' particular constraints and goals in relation to expected profit and their perception of the risk. Socio-economic aspects of pest management consider the constraints imposed by the cultural and economic situation of the farmer on the type of management practices that are appropriate, and the subsequent likelihood of their adoption. The project needs to understand the type of farmers, their needs and resources, their own perception of the problem and their own objectives. The farmer's perception of the pest problem is taken into account since this will influence the likelihood of a practice being adopted, and, the farmer may already have measures of

control based on traditional practice. A farmer's willingness to adopt practices is based on the relative importance of the crop for the farmer's well being. The adoption of control techniques will also depend on their perception of the cost, both monetarily and in time and effort (opportunity costs).

II. CULTURAL CONTROL

Cultural control of insect pests manipulates the environment in such a way as to render it unfavourable to the pest. This is achieved through the use of a variety of techniques; rotation, intercropping, mixed cropping, manipulation of crop sowing dates, weed and field margin management. Cultural controls are mainly effective as a deterrent, and are the first controls around which to build an IPM strategy.

Crop health and hygiene

One of the most important steps in pest control is a healthy soil. Healthy plants are less susceptible to attack by insects or disease. Watering, mulching and manuring are practices that in general promote rapid growth and shorten the time the plant is available for attack, providing the crop with greater tolerance and the opportunity to compensate for insect damage. Pest outbreaks may occur because the crops suffer drought stress caused by high temperatures and decreased water availability.

Field hygiene is a measure aimed at interrupting the life cycle of pests. Do not provide breeding grounds for disease and harmful insects; keep it clean. Remove and burn or bury sick plants immediately. Remove prematurely fallen fruit and crop residues after the harvest, which might be infested with larvae or pupae. These may be composted to return nutrients to the soil, however, virus-infected plants should always be destroyed by burning.

Rotation

The rotation of crops provides a means of maintaining soil fertility so that an appropriate sequence of crops used in rotation can produce better yields than continuous cultivation of the same crop. The type of crops used in rotation is very important for maximizing yield. There is an advantage in using crops that have different rooting habits and thus vary demand between different soil layers. Another factor that could influence the choice of crop types in a rotation is the combination of crops that produces the greatest reduction in pest damage, or prevents a build-up of insect pests. Proper sequencing of crops, so that two successive crops do not share the same disease or insect problem, can effectively break the life cycle of pests. This eventually reduces pest population and makes control easier. Thus, it is best to choose crops for successive plantings which have few common enemies. Crop rotation is especially effective in controlling insect pests in the soil. Suitable crop rotations are presented below.

Crop Rotation in Garden Beds

Bed Division	1st season	2nd	3rd	4th
1.	leaf	fruit	root	legume
2.	fruit	leaf	legume	root
3.	root	legume	leaf	fruit
4.	legume	root	fruit	leaf

Companion Planting

Companion planting is the planting together of certain plants and vegetables in the same bed which help each other to grow or which have different growing habits and can be grown together without harming or taking nutrients from each other.

There are several reasons why certain plant combinations are successful. Different plants have different needs for sun, moisture, nutrients, root space and above ground space. A plant that needs very much sun would possibly grow well with a plant that does not need so much sun. A plant with shallow roots may grow well with a deep rooted plant.

An advantage of companion planting is that it can reduce insect damage in certain crops. For example, crops such as garlic have strong odours that repel certain harmful insects. Insects are more attracted to a plot of cabbages than to a mixed plot of cabbage and garlic. Aromatic herbs, such as mint and basil can be useful companion plants because of their strong odours which repel insects and discourage them from landing in the garden area. To have a good effect the protective plants need to be planted well before plants that need to be protected.

Another advantage is that the competition between plants is minimized, thereby reducing the weakening of one or the other, or both. A weakened plant is more susceptible to insect attack.

A good example of companion planting is cucumbers and corn. Cucumbers grow best with some shade. This shade is provided by growing cucumbers under corn. The corn also benefits from the cucumber vines which cover the ground like a living mulch. Another example of this type of companion planting is with lettuce. Lettuce benefits from the shade of taller crops such as tomatoes or eggplants which have deeper root systems than the lettuce.

Plant Families

Plants within a family share many of the same diseases and insect pests. One can encourage a build-up of diseases or attract more insects by growing members of the same family in the same section of the garden.

Tomato Family tomate, piment, aubergine, tabac	Onion Family oignon, ail, poireau
Cabbage Family chou, chou fleur, navet	Bean Family pois souche, haricot
Carrot Family carrote, persil	Beet Family bettrave, epinard
Melon Family melon, militon, jiraumone, concombre	Sunflower Family laitue, tournesol
Lalo Family lalo	Okra Family gombo

Thus, based on the information presented in the preceding two sections, plants that grow well together and those that do not are listed in the following table:

Vegetable Companions and Antagonists

Vegetable	Companion	Antagonist
Beans	Potato, Carrot, Cucumber, Cabbage most other vegetables and herbs	Onion, Garlic
Bush Beans	Potato, Cucumber, Corn	Onion
Pole Beans	Corn	Onion, Beet, Kohlrabi, Sunflower
Beets	Onion, Kohlrabi	Pole Bean
Cabbage Family	aromatic plants, Potato, Tomato Peppermint, Beet, Onion, Lettuce Chives, Onion, Leek, Peas	Pole Bean
Carrot	Lettuce, Chives, Onion, Leek, Tomato	
Chives	Carrot	Beans, Peas
Corn	Okra, Tomato, Bush Bean, Peas Cabbage, Peanut, Vine Squash, Potato, Cucumber, Pole Beans	
Cucumber	Pole Bean, Radish, Okra, Peas Beans, Corn, Sunflower, Eggplant	Potato, aromatic herbs

Vegetable	Companion	Antagonist
Eggplant	Beans, Vine Squash, Radish, Chinese cabbage	
Leek	Onion, Carrot	
Moringa	Chinese Cabbage, Tomato, Jute, Amaranth, Lettuce	
Lettuce	Carrot, Radish, Cucumber	
Okra	Vine Squash, Chinese Cabbage, Radish	
Onion, Garlic	Beet, Tomato, Lettuce, Carrot	Beans, Peas
Parsley	Tomato	
Peas	Carrot, Turnip, Radish, Cucumber Corn, Beans, most vegetables/herbs	Onion, Garlic
Potato	Beans, Corn, Cabbage, Sunflower	Squash, Cucumber, Tomato
Radish	Peas, Lettuce, Cucumber	
Tomato	Chives, Onion, Parsley, Lettuce, Carrot, Radish, Chinese Cabbage	Kohlrabi, Potato, Cabbage
Turnip	Peas	

Intercropping

Intercropping is a form of companion planting, but one mixes the various plants in the same bed. Intercropping provides a greater total land productivity as well as some insurance against the failure of any single crop. In addition, crops in intercropping systems may improve soil fertility and the availability of alternative nutritive sources as well as reducing the incidence of pest attack. If the garden contains a wide diversity of plant species, both annuals and perennials, it will not be subject to insect devastation because insects are usually specific to a small number of plants. More diverse cropping systems lead to a higher density of insect predators and thus enhance their effectiveness as control agents.

Tillage

Soil tillage as a preventative measure aims at pests which exist as larvae or pupae in the soil or in crop residues. Tillage can markedly influence the soil environment and

affect insect survival either indirectly by creating inhospitable conditions and by exposing the insects to their natural enemies or directly by physical damage inflicted during the actual tilling process. Insect eggs and larvae in the earth can be exposed where they will dry out or are devoured, and eggs on the surface buried at a depth from which they cannot succeed in resurfacing.

Planting Date

Choosing the right time for planting also keeps infestation low. An pest outbreak is usually associated with a particular stage of development of the host plant coinciding with a particular stage in the pest life cycle. The coincidence of an increase of pest population with a crop's most vulnerable period should be avoided. In general, early planting at the start of the rains is essential if the best yields are to be obtained. Early sown crops benefit from a full season's rainfall, suffer less weed competition, and may profit from reduced insect pest infestation. Varying the planting time of crops works as a control if a certain crop, sown at a regular time of the year and watered, is regularly subject to heavy insect attack. The variation serves to break the corresponding cycle between insect and crop development.

Host Plant Resistance

Host plant resistance represents the inherent ability of crop plants to restrict, retard or overcome pest infestations and thereby improve the yield and/or quality of the harvestable crop. In combination with other methods the choice of plant variety, or plant individuals to be reproduced, constitutes a further means of reducing attacks by pests.

Resistance can take a number of forms:

- Insect will not accept a plant as a food source, a place to deposit eggs, or a habitat.
- Insects sicken after feeding on the host plant.
- The plant provides a poor food source for the insect
- Host plants can tolerate insect feeding on the host plant and recover again.

Degree of resistance or susceptibility

A species, variety or individual plant can show different degrees of resistance. Immune varieties are those where the pest has no detrimental effect on the plant. Resistant varieties are those which provide a certain resistance to infestation. Tolerant varieties are those which can tolerate the presence of a pest. Susceptible varieties are those that offer very little defence and can be heavily attacked when pests are present.

It should be noted that the ability to resist pest attack may be lost over several generations. This can be due to degeneration of the resistant characteristics or the pest becoming able to overcome the plant's resistance. It is to necessary regularly to develop new resistant varieties.

Methods for selecting host plants resistance

The most effective way of obtaining resistant varieties is to collect seeds from plants which have demonstrated some resistance under field conditions.

The principle technique for obtaining resistant varieties on the farm is by mass selection.

This consists of selecting the plants in the garden which are not attacked by the pests that are present and have the characteristics of the required variety.

Stages of mass selection

- Identification of individuals within the plot(s) which show no signs of attack by pests that are present and which show very little or no sign of the symptoms characteristic of pest attack. It should be emphasised that this stage is not possible if one is not familiar with the damage or symptoms of caused by the pest, or if the pest is not present in the plot.

- These individuals should not be more susceptible to attack by other pests i.e. resistance to one pest should not mean that the variety is more likely to be attacked by, or less resistant to, another pest.

- The plant should be vigorous and well developed.

- It should be in good condition (show the correct characteristics of the variety), without any deformity.

- The individuals should be marked with a coloured ribbon or label so that they can be easily identified later in the season.

- When mature, the seeds should be collected from the marked plants.

Precautions at harvest

It is extremely important to have followed the growth and development of the plants from which the seeds are collected (F1 generation) and to check for any likelihood on disease. This is because:

- Some plant diseases can be transmitted in the seeds. Plants grown from seeds taken from an infected plant will also be infected with the disease.

- Transport of infected seed from one plot to another will spread the disease.

Strict hygiene rules should be followed from the moment of harvest (seed collection). The principle precautions that should be followed are listed below.

- Avoid touching diseased plants in the field as this could spread disease to the selected plants.

- Make sure that the harvested seeds are uniformly mature, not half ripe and half unripe.

- The most vigorous and healthy-looking seeds should be chosen.

After collection the seeds should be treated carefully (washed if necessary, dried and sorted) before they are placed in a container in an appropriate store.

At the appropriate time of year, the seeds should be sown and the plants that grow to show the required characteristics (resistance to pests, adaptation to environment etc.) should be selected as a 'starter stock' from which the selected variety can be grown.

Vegetative reproduction

Plants grown by vegetative reproduction have all the resistance characteristics of the parent plant.

Vegetative reproduction is when the plant is grown from something other than the seed (e.g. root fragment, rootstock, graft, bulb, cutting etc.) Examples are sugar cane reproduction from rootstock shoots; sweet potato and cassava reproduction from stem cuttings; banana reproduction by stem shoots.

III. BIOLOGICAL CONTROL

The interactions between insect pests and their natural enemies are essential processes that contribute to the regulation of insect pest populations. In situations where this interaction is disrupted, potential pest insects may be released from the constraints imposed by their natural enemies, and excessive pest population growth may occur. Insects can become pests when separated from their natural enemies due to habitat modification that favours the pest, for example in monocultural gardening, or when insecticides have killed natural enemies. The use of natural enemies in pest management is mainly concerned with rebalancing the populations of pest insects and enemies.

The biological control method makes use of living organisms, such as parasites, predators, and even birds to reduce the insect population below the economic damage level. A wide diversity of plants will attract insect predators and is probably the most effective way of encouraging a useful predator population. As mentioned, the technique of intercropping encourages a higher density of insect predators, and strengthens their effectiveness as biological control agents. The planting of flowers, trees and bushes in and around the garden can attract insect predators. In addition, maintaining weed growth in hedgerows and fencing helps in promoting natural enemies by providing additional habitat and thus food sources. Common predatory insects to encourage are: praying mantis, ladybugs, spiders, and wasps. In addition, insectivorous birds as well as lizards and toads can be beneficial.

The application of chemical insecticides in most cases will kill beneficial insects as well as the pest species. Generally, beneficial insect populations take longer to recover than

pest populations. This can lead to resurgence of the pest population or the upsurge of previously unimportant pests. It is essential, therefore, that chemical pesticide applications be minimised and, where possible, chemicals with restricted activity, rather than broad spectrum, are used.

A group of insecticides that are extremely specific are microbial insecticides. The active ingredient in microbial insecticides is insect pathogenic bacteria, fungi, protozoa, viruses or nematodes. In some cases, particularly with the viruses, the microbes are only harmeful to a single species. They also have the advantage of being naturally occurring and environmentally benign and can be produced locally. Some insect pathogenic agents can be used as biological control agents, their release leading to transmission of the disease from individual to individual and eventual collapse of the pest population.

IV. MECHANICAL CONTROL

Mechanical controls use direct mechanical action, such as barriers or traps, to either prevent an insect from being able to cause damage or have access to the crop. Mechanical controls draw on an insect pest's particular characteristics for their effectiveness. For example, numerous insect pests such as caterpillars and slugs will not cross barriers of ashes, as contact with ashes can cause them injury. Certain caterpillars cut young vegetable plant sprouts at ground level; a small twig inserted next to the stem prevents the caterpillar from being able to get its mouthparts around the stem, thus preventing it from cutting it.

In addition, by the use of traps, mechanical controls can be used to limit the number of pests present in the garden. By knowing the habits of particular pests, the farmer can determine where to look for a pest, and even a means of trapping it. An example: slugs and crickets prefer moist dark spots for concealment during the day. They hide under logs, rocks; any object that will shield them. The farmer can set out items to serve this purpose, and then collect and destroy the pest when they profit from the presence of the cover, which is effectively a trap.

One of the most traditional and frequently used methods of mechanical control is hand-picking. Caterpillars, grasshoppers, and other insects tend to group when they are young. If they can be hand-picked before they scatter, they will cause little damage. Larger larvae or adult insects may also be effectively hand-picked in small areas. Egg clusters can also be removed from plants before hatching.

The key to effective mechanical control is knowledge of the insect; where it hides, feeding habits, placement of eggs, etc. This knowledge is gained through observation, both of the garden and the surrounding area. From this observation, the farmer will not only be able to learn what type of damage particular insects cause, but also where it is most likely to be found, thereby aiding in an effective control decision.

V. CHEMICAL CONTROL

This consists mainly of using natural and synthetic chemicals, known as insecticides, to kill insects. This is the most common method used at present because insecticides are

easy to apply and effective. The natural insecticides are manufactured from plants, thus, they are referred to as botanical insecticides.

There will always be certain insect pests that cannot be entirely controlled by any means other than insecticides. However, for the majority of pest species the use of insecticides should only be a last resort, for situations where it is known that methods such as host plant resistance, natural enemies, and cultural controls have not been effective in limiting pest population development. Only when no alternative methods or combinations of measures are available should an insecticide be used on its own as a control measure.

In light of the cost, risks, and the lack of availability of chemical pesticides, farmers should be encouraged to minimize the need for their use by undertaking the following steps:

1. Only use insecticides upon evidence of insect pest presence. Treatments made without confirmation and evident need waste scarce resources and can have a negative effect on beneficial insects and actually encourage pest population development by causing the death of pest enemies.

2. Improved insecticide formulation and placement. Often, pesticides are sold in generic packaging which provides no details on the product and its use. This results in ineffective and often inappropriate formulation and use, possibly with more negative than positive effects.

3. Use of crop rotation systems to avoid carryover pests from one season to the next and a gradual build-up of the pest population. This topic was covered previously under cultural pest control techniques.

4. Selection of cultivars that have demonstrated resistance to pest attack.

5. Respect of the appropriate crop sowing period to avoid attack.

6. Adoption of controlled weed growth practices as compared to total weed suppression so as to encourage natural enemies of pests.

7. Use of microbial insecticides.

8. Protection of parasites/predators of pests.

9. Appropriate cultivation techniques, such as tillage, intercropping, association and companion planting.

10. Encourage natural predators by maintaining biological diversity among plants and in the soil system.

But, as mentioned, there will always be pests that require control methods involving insecticides. In these cases, the use of botanical or microbial insecticides is

encouraged. The short term effectiveness of botanical insecticides is generally not as great as chemical insecticides. But, they have some or all of the following advantages:

- Lessen the risk of pests developing a resistance to the treatment
- Less destructive of insect pest predators and parasites
- Less harmful to people and farm animals
- Do not affect water supplies
- No dependency on external supply of chemical insecticides; use local materials
- Costs less

VI. INSECT PEST MANAGEMENT STRATEGY

When designing an IPM strategy, a farmer needs to understand the way that the cultivated land and the surrounding area are associated. It is most helpful when the farmer must decide which control and prevention measures are best suited to the circumstances. The farmer needs to consider:

- What types of insects pests, as well as predators and parasites, are present in the farming area *and be able to recognize them.*
- Knowledge of their habits.
- Insect population patterns and rhythms; seasonality.
- Vulnerable stages of insect development.
- Season or stage of plant development when it is most vulnerable to attack.
- Alternate plant hosts for insect pests.

One of the most important tools available to the farmer is observation. It is by observation that the farmer can gain an understanding of the interactions in and around the garden. The knowledge gained is the key for proper decision making and in the selection of control measures to be undertaken which are suited to the local conditions. The farmer should know which insect to control. The farmer needs to make sure that the pest is really a pest and causing damage. He/she should be able to recognize beneficial insects and encourage their presence.

A basic IPM strategy can be summed up in three steps; eviter, empecher, eliminer.

Eviter

The basic aim of the first stages of an individual IPM program should be to avoid an initial infestation. This is the goal behind the cultural controls. A farmer who is using sound agronomic practices, such as rotation, association, soil amendments, respect of planting dates, tillage and seed selection will most likely be subject to fewer insect

attacks than a farmer who does not practice these techniques. Plants will be healthier and thus more resistant to attack, and the physical set-up of the garden will be unfavourable to pests. Any infestations that occur in these gardens are likely to be less severe, due to basic conditions that don't favour insect pest development.

Empecher

As noted earlier, there will always be insect pests present in the garden. The idea is to prevent them from multiplying to levels that result in economic damage to the crop. This is aided by biological control methods; the presence of natural predators and parasites help keep the insect pest levels to a minimum. Cultural controls can also fall into this category as the dispersal of host plants throughout the garden in a mix with non-host plants can inhibit population development. In addition, mechanical means, such as barriers, can prevent the insects from free movement about the garden, thereby reducing the damage that they can inflict.

Eliminer

In the case that, in spite of having implemented the preceding steps, an insect pest infestation reaches proportions such that it starts causing unacceptable levels of damage, the farmer will have recourse to the use of means to reduce the pest population to a level below the economic threshold. This can be through the use of mechanical controls, such as traps, but most often it will be through the use of chemical, botanical or microbial insecticides, although due to there safety and specificity some microbial insecticides may be used at an earlier stage to prevent pest populations reaching an economically important level. The treatments should be made only upon confirmation and identification of the particular pest to be controlled. Based on this identification, an appropriate method of treatment and the accurate placement thereof can be decided to have the desired effect on the insect pest while causing the least possible damage to non-target insects, specifically insect predators. The aim of the control operation should not be to completely eliminate the pest - this is likely to be impossible or impractical, and may be detrimental in removing completely the host insect required to maintain a population of beneficial insects.

VII. INSECT PESTS IN BIO-INTENSIVE GARDENS

See following table, which is in French. Full descriptions of pests in English can be found in King, A.B.S. & Saunders, J.L. (1984) The Invertebrate Pests of Annual Food Crops in Central America, ODA, London and in English and French in Schmutterer, H. (1990) Crop Pests in the Caribbean, GTZ, Germany.

IDENTIFICATION DES INSECTES PESTES DANS LES BIG

CULT-URE	INSECTE	NOM LOC/CREOLE	DESCRIPTION INSECTE	SYMPTOMES/DEGATS
Chou	Teigne plutella sp.	Cheni	Petite chenille transparente et brillante à travers laquelle on distingue les parties internes de couleurs vertes	Dévore les feuilles du chou en laissant de mul-tiples petits trous. Les feuilles sont tissées en tube et le chenille se cache dedans
	Peut-être Noctuidae	Cheni Woulo (Machelanwit)	Chenille 1 1/2" de long de couleur marron rappelant la couleur de la terre desséchée et se déplacant par réptation d'ou son nom de woulo	Coupent les racines. Creusement des racines.Chenille sou-terraine attaquant la nuit
	Arpenteuse du chou Tricoplu siani	Cheni	Chenille d'environ 1"-1 1/2" de couleur verte ou marron selon le stade et se déplacant en faisant le gros dos	Dévore les feuilles du en laissant des traces plus ou moins importante surtout sur les rebords
	Pieride Pieris Brassicae	Cheni	Chenille d'environ 1 1/4"-1 1/2" de long, poilue, de couleur jaune tacheté de noir	Dévore les feuilles du chou surtout sur les re- bords. Attaquent souvent en groupe.
		Cheni an liy	Chenille de 1/4"- 1 1/2" de long, noir avec les rayures longitudinal jaune et marron, tête un peu plus gonflée par rapport à son corps	Dévore les feuilles, en laissant des grands trous

CULTURE	INSECTE	NOM LOC/CREOLE	DESCRIPTION INSECTE	SYMPTOMES/DEGATS
Chou	Pucerons cendre ou verts Trialeurodes vaporaxiorum	Pichon	Colonie de minuscules insectes turgescents le plus souvent de couleur gris-vert	Sucent la sève en laissant de minuscules trous sur la face inférieure des feuilles de chou. Rétrécissement des feuilles
	Punaises (Pentatomidae?)	Pinez	Insectes à forme plus ou moins triangulaire de couleur verte, marron ou noire. Mauvaise odeur caractéristique. Attaquant le plus souvent en bande	Elles sucent la sève àtravers les feuilles.
	Maroca Larve de coleoptere	Mawoka Tyogann	Grosse larve blanche ayant l'aspect d'un gros ver à tête noire	Coupe et dévore les racines
	Petite chenille au coeur du chou peut-être Elula sp	Chifon	Petite chenille de couleur crême avec des stries marron sur le dos	Dévore les petites feuilles au coeur du chou pourriture de ces petites feuilles. Cette chenille se cache souvent à l'intérieur d'un cocon de fil de soie.
	Courtilière (Gryllidae)	Kriket	Sorte de criquet vivant dans le sol, de couleur marron	La courtilière coupe les feuilles et les emporte sous le sol. Elle coupe également les racines, attaque surtout la nuit
	Limace (Agriolimax)	Kalmanson		Coupe les jeunes plantes au niveau du collet. Dévore les feuilles surtout aux rebords, laissent les traces glissants par terre et sur les feuilles

• CULTURE	INSECTE	NOM LOC/CREOLE	DESCRIPTION INSECTE	SYMPTOMES/DEGATS
Epinard	Ver Borer	Ve Blan	Larve de mouche de couleur blanc jaunâtre	Le ver creuse des tunel- les dans les tiges prin- cipales. Cela entraine le flétrissement de la plante puis sa mort. L'intérieur des plantes attaquées pourrit et prend une couleur foncée
	Teigne Plutella sp	Cheni	Petite chenille de couleur transparente, brillante qui laisse entrevoir de l'exté- rieur les parties internes verdâtres de l'insecte	Dévorent les feuilles en y laissant des trous. Les feuilles ataquées se replient. La larve tisse une sorte de fil de soie a l'interieur des feuilles repliées
	Limace (Agriolimax)	Kalmanson		Coupe les jeunes plantes au niveau du collet. Devore les feuilles surtout aux rebords, laissent les traces glissantes par terre et sur les feuilles
Aubergine	Punaises (Pentatomidae?)	Pinez	Insectes à forme plus ou moins triangulaire de couleur verte, marron ou noire. Mauvaise odeur caractéristi- que. Attaquant le plus souvent en bande.	Durcissement des tissus piqués (fruits)
	Mouche Blanche (Aleyrodidae)	Mouch	Adult fly is 1mm long with white wings and a body powdered with a white floury secretion	Suck sap exude a secre-tion that encourages black fungus development on leaves
	Pucerons (Trialeurodes?)	Pichon	Colonie de petits insectes turgescents de couleur noire	Rétrécissement des feuilles attaquées présentant de petites boules
	Fourmis (Fourmicidae)	Foumi	Approximativement 1mm de long, de couleur rouge	Tunnel into stems causing terminal ends of branches to die back

CULTURE	INSECTE	NOM LOC/CREOLE	DESCRIPTION INSECTE	SYMPTOMES/DEGATS
Tomate	Punaises (Pentatomidae?)	Pinez	Forme triangulaire de couleur verte, marron ou noire. Odeur caractéristique	Durcissement des tissus sur les fruits piqués.
	Maroca (Larve de coleoptere)	Mawoka (Tyogann)	Larve se présentant sous la forme de gros vers blancs a tête noire	La larve dévore ou creu-se les racines flétris-sement mort
	Pucerons (Trialeurodes?)	Pichon	Colonie de petits insectes turgescents de couleur noire	Minent les feuilles at-taqués en sucant la sève
	Chenilles	Cheni	Divers	Broutage des feuilles en y laissant des perforation
	Mouches	Mouch	Larvas are white, legless, asticot, about 3mm long	Larvas bore into fruit, eat pulp, fruit drops prematurely
	Fourmis (Fourmicidae)	Foumi	Divers	Dévore l'intérieur des semences et détruit leur pouvoir germinatif
	Limace (Agriolimax)	Kalmanson		Coupe les jeunes plantes au niveau du collet. Dé-vore les feuilles sur-tout aux rebords, laissent les traces glissantes par terre et sur les feuilles
Piment	Maroca larve de coleoptere	Mawoka (Tyogann)	Gros vers blancs à tête noire	Creusement et/ou brouta-ges racines flétrisse-ment, mort
	Chenilles	Cheni	Couleur verte, 1-3 cm de longueur	S'attaquent aux feuilles et aux fruits qu'elles dévorent
	Punaises (Pentatomidae?)	Pinez	Forme triangulaire de couleur rouge et noire groupées sur la tige et les feuilles odeur caractéristique	Durcissement des tissus piqués (toutes les par-ties de la plante)

CULTURE	INSECTE	NOM LOC/CREOLE	DESCRIPTION INSECTE	SYMPTOMES/DEGATS
Papaye	Vers	Ve	Larve de 1 cm, couleur blanche, la tête jaune	Pénêtrent à l'intérieur des fruits qu'ils dévorent
Pois souche naine	Bruches (Curculiondae?)	Mit	2 mm de long, couleur gris cendre, avec un bec, avec une carapace dûre	Creusent des trous dans les pois secs sur pied
	Chenilles (Plutella?)	Cheni	Chenille transparant et brillante, couleur vert	S'attaquent aux feuilles et aux gousses
	Punaises Nezarra viridula?	Pinez	Triangulaire, couleur vert, marron, ou noir attaquent en bande	Piquent les gousses et en sucent le contenu surtout par temps sec
	Limace (Agriolimax)	Kalmanson		Coupe les jeunes plantes au niveau du collet. Dévore les feuilles surtout aux rebords, laissent les traces glissantes par terre et sur les feuilles
Toutes les jeunes plantes	Criquets et Courtilières (Gryllidae?)	Kriket	Insects bruns ou marron avec les pattes postérieures musclées et allongées leur permettant de sauter. Les courtilières sont des insectes souterrains.	Broutage des parties aérienne des jeunes plants (criquets). Les courtilières coupent puis dévorent les racines. Elles sortent de leur terrier pour dévorer les parties aériennes qu'elles emportent sous le sol
Gombo	Fourmis (Fourmicidae)	Foumi dou	Petit fourmis rouge	Piquent la tige principale et les fruits, en creusant des trous, ronge l'intérieure du fruit

INSECTICIDAL PLANTS

The following solutions can be prepared and used individually, but farmers may find a mixture of two or more of the insecticidal plants to be more effective across a broader range of pests. For instance, piment-onion, tobacco-piment-mint, and tobacco-piment have been shown to work effectively together. In addition, experimentation may result in the modification of the proposed proportions, in that the farmer discovers that a certain change provides better results.

Annona

Pulverize the seeds, which are then mixed with water. The mixture is left to soak for several hours. If a spray is to be used, filter out the Annona particles. If the solution is to be poured over plants, the Annona particles can be left. Effects of the treatment may take up to 2-3 days to be seen. The solution is capable of killing insects, their larvae, and serves as a repellent and antifeedant.

Piment

Boil a small pot of well chopped peppers in 3 litres of water for 15 to 20 minutes. Add a small ball of soap (about 3-4 cm in diameter) and stir well to mix the two ingredients (the soap helps to stick the solution to the plants). Add a further 3 litres of water, leave to cool and filter. Instead of boiling the peppers, they can be soaked in the water for 4 or 5 days; add the soap and follow the procedure given above. The mixture can be sprayed or sprinkled on the plants. The solution can kill insects, but also serves as a repellent and antifeedant.

Neem

Production of oil - Dried neem seed is required. They should be shelled. Lightly crack the shells in a mortar to free the seed from the hull. The seed grains are then pounded until they form a brown, sticky mass. A little water is added to form a paste to allow the formation of a ball. The ball is kneaded for several minutes over a bowl until oil collects on the surface, then pressed firmly. Oil is removed by drops. Alternate kneading and squeezing will separate the oil.

Neem oil- 2-4 ml/kg is used to protect dried haricots and beans against "mit", and the prtotection of cereals (wheat, maize and sorghum). Beans/cereals and the oil should be well mixed. To remove the oil from the beans (cereals) before eating, place them in cold water for five minutes.

Preparation of aqueous solution - Fallen fruits are collected from underneath the trees. The fruit is removed and the seeds should be washed and dried to avoid rot. Begin the preparation one day before it is needed. Add 25 gr of ground neem kernals or 50 gr of ground seed to one litre of water and leave overnight. Filter the resulting emulsion through muslin cloth to remove large particles. The extract is now ready for

use. Treatments to infested crops should be made at weekly intervals; in the case of attack by crickets and grasshoppers treatments should be made twice a week.

Neem extract is used to kill insects, but also works as a repellent, and an antifeedant.

Tobacco

Boil two handfuls of dried leaves in 3 to 4 litres of water for 15 to 20 minutes. Add 30 gm of soap (a ball approximately 3 - 4 cm in diameter) and stir while the mixture cools. Add a further 3 to 4 litres of water and filter the mixture; it is now ready. The mixture can be applied to infested plants by spraying or flicking on with a palm leaf, brush etc. BEWARE!!! This solution is very poisonous. Neither animals or humans should drink the solution. Do not store quantities of the solution in the house. Crops should not be harvested for at least a week after treatment and should be washed well before eating.

Tobacco can also be used as a powder. Save cigarette ends and cigarette ash. Grind and mix with cinder ashes.

Tobacco produces a strong insecticide, and can serve as a repellent, too.

Basil

Leaves and ripe seeds (1 pot) are pounded in a mortar and then soaked in water (2 gallons) overnight. The mix is filtered and then sprayed or sprinkled on the crop. In certain cases, the solution can kill insects, but most often is used as a repellent.

Eucalyptus/Mint

Usually used to protect grains in storage. Ten to twenty leaves of Eucalyptus (same volume for mint) should be ground and mixed with each pot of stored produce. The Eucalyptus or mint serves as a repellent.

Tomato

Tomato stems are finely shredded, covered with hot water, and left to stand for 5 hours. The solution is filtered and then used as a spray. The spray irritates insects, especially caterpillars and moths, which prevents egg laying and feeding.

Onion

Grind onions and mix with water (1 part onion to 6-10 parts water). Add a little soap powder, strain, spray or sprinkle on crop. This solution is primarily a repellent.

Gliricidia

Extract juice from leaf and stems using the same method as for tomato. Mix with water and spray. Fresh stems with leaves can be placed between plants to deter insects.

Crush stems to free latex, soak in water, filter, spray and sprinkle on plants. The latex in the plant is a strong insecticide.

MIXTURES

Flour preparation: A spray made from 2 cups flour and 5-10 litres water is sprayed onto plants infested with pichon. The treatment should be done in the morning. The heat of sun dries the mixture and the insects are encrusted in flour and die. The flour falls off the plant as it dries.

Citrus + banana peel: let banana and citrus peels soak in a pail for several days. Spray mixture on crops and place spent peels at the base of plants. Serves as a repellent.

Vegetable oil: Mix one part oil with 5 parts water and apply with sprayer. The solution needs to be frequently mixed to minimize oil and water separation. Controls insects by coating their bodies and suffocating them or by preventing the deposit of eggs on a plant.

Soap and water: 3 tablespoons soap/gallon water. Stir together and use as a spray. A small area should be tested first to ensure that the preparation does not damage the crop plant.

Kerosene/soap: 1/2 cup soapy water, 1/4 tablespoon kerosene, 1 litre water. The ingredients are mixed thoroughly, without any free oil remaining. Heating the mix aids in forming the solution. The solution should be mixed when ready with 10-15 parts water. This is a strong, broad-range insecticide and should only be used in cases of severe infestation.

Manure tea: insect repellent as well as a starter solution for transplanted plants. Helps against yellowing of tomato leaves in the dry season. One part dry manure to 10 parts water by volume. Soak for several days until water is the colour of strong tea. Spray on plants as well as watering soil.

Aromatic herbs and soap: Chop and mix one garlic, one onion, one tablespoon hot pepper and mix with one quart water. Let sit for one hour then add one tablespoon soap. Place the mixture in a tightly covered jar and store in a cool place for one week. This spray serves as a repellent.

Cheni, Cheni an liy, Cheni woulo, Chifon

Control measures:
- Encourage natural enemies
- Intercropping
- Hand-picking of egg clusters, caterpillars
- Spread ashes on leaves
- Sprays: Annona
  - Neem
  - Tobacco (avoid for plants in Tomato family)
  - Tomato
  - Piment
  - Gliricidia
  - Mixtures (vegetable oil, soap, kerosene)

Cheni woulo (souterraine)

Control measures:
- Tillage
- Weed control
- Spread ashes around base of plant
- Insert a matchstick or twig down the side of the stem; caterpillar can't cut stem
- Hand-picking; dig around base of cut plants for caterpillar
- Sprays: Tobacco (avoid for plants in Tomato family)
  - Neem
  - Gliricidia

Pichon

Control measures:
- Encourage natural enemies; companion planting/intercropping
- Removal and destruction of heavily infested leaves (cabbage)
- Soil amendments
- Sprays: Annona
  - Neem
  - Tobacco (avoid use on Tomato family)
  - Piment
  - Gliricidia
  - Onion
  - Mixture (soap, kerosene, vegetable oil, flour)

Pinez

Control measures:
- Hand-picking
- Sprays: Neem
  - Annona
  - Tobacco (not on Tomato family)
  - Gliricidia
  - Mixture (kerosene)

Mawoka

Control measures: Tillage
Hand-picking; dig around damaged plants
Rotation to avoid successive vulnerable crops

Kriket

Control measures: Board trap
Sprays: Annona
Neem
Piment
Tomato
Gliricidia

Kalmanson

Control measures: Board trap
Hand-picking
Spread ashes around base of plant, on leaves
Sprays: Neem
Piment
Annona
Tomato
Gliricidia

Mit

Control measures: Host plant resistance
Harvest pods before they become dry
Sprays: Neem
Piment

Stored pois: Eucalyptus
Neem
Mint
Spread ash

Mouch

Control measures: Host plant resistance
Encourage natural enemies
Collect infected and dropped fruits and burn or dispose of properly
Sprays: Tobacco (not on Tomato family)
Neem
Piment
Tomato
Onion

Gliricidia
Mixtures (kerosene, soap)

Ve Blan

Control measures: Cut infected stem and burn

Foumi, Foumi dou

Control measures: Pour boiling water on nests
Sprays: Piment
Annona
Tobacco
Mixtures (kerosene)

Appendix 5: Experimental techniques

The effect of living hedgerows on pest population

a. Insect sampling with a sweep net.

Living hedgerows can be sampled through sweep netting of the hedgerows. The use of a sweep net is a common technique for sampling of insect populations and relies on the use of a net to capture insects on the plant. It can only be effectively used on plants which can bend with the passage of the net. It is essential that the technique used for sweep netting is standardised. The net can be constructed by taking mosquito netting and tailoring it like a cone (approx. 2 feet long). Stitch this to a wire ring (diameter 15 inches). Fix the wire to a wooden handle (approx. 2 feet long). The technique of sampling is to swing the open net through the vegetation using a pendulum swing, as if you were sweeping a sidewalk with a broom. In short vegetation, swing the net as deep as possible without taking too much dirt into the net. In tall vegetation, sweep only deep enough to keep the upper edge of the sweep net opening even with the top of the vegetation. Sweep one stroke per step while walking at a casual pace. It is suggested that a 10 metre length of hedgerow is sampled on each occasion. Sampling should be undertaken at approximately the same time of day on each occasion, as insects tend to move up and down the plants at different times of the day. Monthly samples should be taken from different sites throughout the season. Insect should be collected into labelled plastic bags, identified and counted.

b. Pest Damage

Damage levels should be assessed visually across the field starting at the hedgerow and walking at right-angles to it. Ten samples should be taken in each field, each sample consisting of a visual estimate taking at the point the observer is standing of the degree of damage using a scale of 0 to 10 (0 - 100% of plant damaged) and noting the type of damage (virus disease, insect feeding etc.). The first sample should be taken next to the hedgerow and then at 2 - 5 metre intervals, depending on the size of the field. Assessments should be made monthly.

Pest thresholds

Often plants can tolerate and recover from insect or disease attack, such that there is no significant effect on yield. It is therefore important to know the pest density or level of disease at which control measures need to be applied to prevent economic loss. Economic loss is the point at which the value of the crop loss (physical or financial) exceeds the cost of controlling the pest (effort or financial); this is known as the action threshold. Some threshold levels for particular crop/pest interactions are presented in the text of this report, however, these need to be refined for the particular conditions encountered in Haiti.

Action thresholds are determined by quantifying the level of crop loss and relating this to the level of infestation. This should be done for each of the major crop/pest interaction which are described in the report text. The mechanism for determining this

can vary, but it is suggested that damage levels in a crop are determined in a similar way as described above. i.e. 10 - 20 plants are taken at random in a plot and the amount of damage visually assessed, either on a scale of 0 - 10 for leaf damage, and if appropriate fruit damage or the numbers of damaged and undamaged fruits. The numbers and species of pest present on the plants should also be assessed. This should be carried out on two occasions each month. At the end of the season the observed plants should be harvested and yield assessed in terms of weight, number of undamaged and damaged fruits and marketability. This can then be related to the level of pest attack. At least five plots with different levels of pest attack need to be monitored for each crop/pest interaction. It will then be possible to draw a graph relating pest attack (number insects/degree of damage to final yield). Final yield can be defined as value, addition of a value (cost) for pest control measures to the graph will result in an estimate of the action threshold (number of insect, degree of damage) at which pest control interventions should be undertaken. For further information refer to the FAO manual on crop loss assessment methods.

Determination of the level of natural control

All pests have natural enemies and these can play a significant role in maintaining pest problems below the action threshold. A major goal of an IPM programme is to *encourage* and *maintain* the presence of natural enemies through the manipulation of the environment and the minimum use of harmful pesticides.

Insect natural enemies consist of predators, parasites (parasitoids and nematodes) and pathogens (bacteria, fungi, protozoa and viruses). Predators can include birds, mammals and reptiles, but in this report I will only deal with predator insects and spiders. It is important that the level of natural control is assessed so the effect of control operations on natural enemies is determined. It is also important to determine what natural enemies are already present before the option of introducing a natural enemy from elsewhere is considered.

a. Determination of the number and species of predators

The predator population present in a crop can be sampled by the use of sweep nets to collect insects active on the plants; the methodology of using a sweep net is described above (this will also, of course, capture some parasitoids). Predators that live on the soil surface can be sampled using pitfall traps - smooth sided cups sunk into the soil and flush with the soil surface, into which insects fall and cannot escape. A small amount of water and ethylene glycol in the cups will prevent the insects escaping and from eating each other. Captured insects can be identified using an appropriate key (it is suggested that reference is made to the FAO Manual for Biological Control) or sending samples (stored in 80% alcohol) to an expert entomologist. The importance of each predator can be determined by direct observation of the plant - which species are seen to be eating the pest species - or, by placing captured predators in a jar with the pest species and seeing which of the predator species attack the pest.

b. Determination of the level of parasitism and species of parasites

This can be achieved through collection of pest species and rearing in containers. The pest insects should be carefully collected and placed individually, or if appropriate in groups, in glass jars containing the pest's natural food. The pest species is allowed to develop and, parasites, if present will emerge or the insect will succumb to a pathogen. From this an estimate of the level (%) of parasitism and disease can be estimated. However, this will only be a crude estimate as different parasites attack different stages of the pest e.g. egg or larva, and unless all stages are collected an accurate estimate cannot be made. Moreover, parasitised insects tend to develop more slowly than unparasitised insects. Thus, depending on when the collection of the insects is made, it is possible that many of the healthy insects in the population have already passed through their life-cycle. Finally, collected insects are normally placed under stress, this can result in death from unknown causes, or an increase in the level of disease which can overestimate the effect of pathogens. However, despite these drawbacks this method will give a. an estimate of the level of parasitism and disease (unknown deaths should be discounted) and b. what parasitoid species and pathogens are present.

Identification of parasites is difficult; emerged parasitoids should be allowed to develop to the adult stage if possible. Identification can be made using appropriate keys, taking into account host species from which the parasitoid emerged. Samples may need to be sent to expert entomologists. Parasites can also include nematodes, although these are often classified along with the pathogens as microbial control agents. Pathogens can be identified through symptoms observed and microscopy. Description of methodology is given in the AF Manual of Biological Control.

c. Determining the effect of parasitoids and predators.

The effect of parasitoids and predators can be assessed in the field by comparing pest attack in small sub-plots or plants where the beneficial insects have been excluded, to those where they have not. Comparisons can be made on the basis of number of pests present and level of damage.

Ground dwelling predators can be excluded by placing a barrier around the plot, e.g. a length of guttering around, to give a continuous pitfall trap. Placement of normal pitfall traps within the plot will indicate when the predator population is low compared to a control plot without a barrier.

The use of an exclusion cage will prevent entry of most predators and parasitoids. The cages consist of a frame covered with fine cloth or metal screening which can be placed over the plants. The presence of the cage will affect the microclimate inside; this will affect both plant and pest population. It is therefore suggested that 'control' plots also are covered with cages, however these cages should have a number of large holes in and be lifted slightly off the ground (on bricks) to allow the entry of beneficial insects (note: some pest species will also be able to enter). Comparison of control plots to exclusion plots over time (sample every week) will give an estimate of the effect of the beneficial insects. It is recommended that 10 replicated are made.

The combination of the results of the exclusion cages, plus an estimate of the level of disease from the insect collections will give an estimate of the total level of natural control due to these organisms.

The isolation of a naturally occurring pathogens will open up the possibility of developing a capability for the local production and use of a microbial insecticide. It is recommended that if a pathogen is isolated an expert organisation such as NRI is consulted on the possibility of developing this into a microbial insecticide.

Determination of effective doses for pesticides

It is important that the appropriate dose of pesticides insecticide is used when it is necessary to control a pest. Commercially produced pesticides have recommended application rates and these should be adhered to. Appropriate application rates for locally produced neem should be accurately determined for different pest species. This can be achieved by standardising the neem solution produced (gm of seed per litre e.g. 500g/10 litres of water) and applying to the crop at varying rates. Thus a plot is divided into 20 sub-plots, these are labelled 1 to 20. Neem should be prepared at 4 rates: a.1000g/10 litres; b. 500g/10 litres; c. 250g/10 litres; d. 125g/10 litres. Each rate (treatment) is applied to 4 of the sub-plots; 4 plots are left untreated (untreated control)

e.g. a = plot 2, 5 9, 15
b = plot 1, 7, 10, 19
c = plot 8, 13, 17, 20
d = plot 3, 6, 12, 14
control = plot 4, 11, 16, 18

The number of insects and level of damage is counted before application of the treatments and one week after; these are compared for the different treatments and control. The treatments should be reapplied to the same plots after one week and a similar assessment made. If considered desirable this can continue throughout the season and the yield obtained from each plot estimated. A graph can be plotted of damage/insect numbers/yield against dose which should indicate the dose at which the most cost-effective control is obtained.

Similar experiments can be undertaken with other botanical insecticides (see Appendix 4 for candidates), other alternative control measures such as use of ash and with locally isolated insect pathogens.