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PEST SURVEY AND MANAGEMENT OPTIONS IN HAITI'S AGROFORESTRY TREE NURSERIES

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ABSTRACT

Owing to mounting concerns about pesticide application and safety practices and the nature and extent of pest problems in Haïti's Agroforestry Outreach Project tree nurseries, an insect pest and disease survey was conducted during the winter dry season of 1987 from February 16 to March 31 in eighteen of the Project's forty or so tree nurseries. This survey was conducted by the Consortium for International Crop Protection at the request of the U.S. Agency for International Development.

The survey's results indicate that the insect pest and disease problems are far ranging, causing moderate (20 to 30%) to extensive (80% and higher) losses of tree seedlings, sometimes forcing abandonment of one or several tree species from nursery production. Losses in the field in terms of survival and suboptimal growth and development accruing from poor health in the nursery could not be appraised but could be significant.

It appears that none of the enumerated insect pest and disease problems are insurmountable and that seedling mortality and unthriftiness can generally be attributed to less than optimal nursery management, especially as concerns plant watering, spacing, and shading, and to the nursery personnel's unawareness of pests and inability to diagnose and correct the causes, biotic or abiotic, of seedling loss and damage.

Appropriate pest management actions, programs, and long-term strategies have been recommended wherever applicable and problems still lacking fundamental knowledge and awaiting further research are indicated.

IPM is discussed in the agroforestry tree nursery context as applies to the humid tropics, the nursery personnel's low education and management skills, and the socio-economic setting of a developing country experiencing severe deforestaration and soil conservation problems on account of a high population pressure on its landbase to provide fuelwood and food.

LIST OF TREE SPECIES

Acacia	*Acacia auriculiformis*
Acajou	*Swietenia macrophylla*
Bois cabrit	*Columbrina arborescens*
Cassia	*Cassia siamea*
Casuarina	*Casuarina equisetifolia*
Ced	*Cedrela odorata*
Chadeque	*Citrus grandis*
Chen	*Catalpa longissima*
Coffee	*Coffea arabica var typica*
Eucalyptus	*Eucalyptus camaldulensis*
Frene	*Simaruba glauca*
Leucaena	*Leucaena leucocephala*
Mango	*Mangifera indica*
Neem	*Azadirachta indica*
Papaya	*Carica papaya*
Saman	*Samanea saman*
Taverno	*Lysilona latisilique*

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INTRODUCTION

Haïti is a developing country facing acute deforestation and soil conservation problems by virtue of an increasingly high population pressure on its landbase to provide fuelwood and to grow more food. In an effort to prevent, and hopefully reverse, further ecological degradation several international organisations such as the Pan American Development Foundation (PADF) and CARE, under the sponsorship and assistance of U.S. Agency for International Development, have set up forest and fruit tree nurseries in cooperation with long established and active Private Voluntary Organisations (PVOs) with the aim of providing tree seedlings, free of charge, to peasant farmers for planting as fuelwood and fruit cash crops. The establishment of this reforestation program has been overwhelmingly successful owing to the integrated community development approach promoted and fostered by PVOs and to the economic incentive of growing trees as a cash crop, which peasant farmers can manage and harvest at their discretion. While peasant farmers find an immediate economic interest in growing trees additional benefits such as improvement of soil fertility and structure, erosion control, and production of livestock fodder accrue.

Although a total of nearly 7 million seedlings are produced twice a year during Haïti's winter and summer dry seasons for outplanting at the beginning of the spring and fall rainy seasons (the outplanting of trees at the beginning of the rainy season ensures higher survival in the field), this number falls drastically short of the country's needs which the World Bank currently estimates at 25 million trees cut down yearly. However, as small as this contribution to Haïti's reforestation needs may seem, it is nonetheless valuable as it is hoped that repopulation of the country with trees may be accomplished through self-seeding, once enough trees have been outplanted and that peasants have learned to regard trees as a valuable crop requiring proper care and tending. It is therefore in the interest of PADF, CARE, and AID to ensure that this little goes a long way by keeping seedling mortality low, thus making efficient use of the nursery resources, and by producing healthy quality tree seedlings which grow fast, develop well, and have a high survival rate under a wide range of field conditions.

One of the aspects of quality tree seedling production and nursery use efficiency that has received attention of late is pest management. At the AOP's onset, it was anticipated that there would be no need for pest control but the realization of its indispensability soon came. Pressed by the seriousness and urgency of the situation, nursery personnel took upon themselves to apply chemical pesticides in the hope to halt destruction and disablement of seedlings by insect pests and diseases.

Owing to mounting concerns about pesticide application and safety practices and the nature and extent of pest problems in the AOP nurseries, an insect pest and disease survey was conducted during the winter dry season of 1987, from February 16 to March 31, in eighteen of the forty or so Project's nurseries, distributed proportionately over the main geographical areas of Haïti. Two to three representative nurseries were selected from each of the following regions and visited in the order listed: South-East (Jacmel area), South-West Peninsula (Les Cayes area), North-East (Cap Haïtien area), Central Plateau North (Hinche area), North-West Peninsula (Bombardopolis area), and Central Plateau South (Mirebalais area).

Each visit consisted of an extensive investigation of nursery and pest management practices and a survey of insect pests and plant diseases. Insect pests were collected and preserved either as dried specimens or as alcohol-preserved specimens, depending on the type of insect. Diseased plant material was collected and dried using a plant press and later constituted into a Herbarium collection. Pest identification was carried out based on both experience and reference documentation and keys. Complete and thorough identification was not always possible due to unavailability of lab facilities and equipment such as microscopes, autoclaves, culture media for fungi and rearing cages for insects, and the non-existence of Insectarium and Herbarium collections of the country's insect pests and plant diseases with which to compare collected specimens. However, at least the pest's category, and usually the most likely genus, were provided based on characteristic features and symptoms. Whenever identification is tentative and/or needs to be confirmed it will be indicated as such.

Pest management recommendations for particular pest species for which sufficient fundamental information is available and for which pest management tactics and strategies have been worked out and shown effective were given wherever the pest's damage status justified it.

Although the current pest survey and the concomittent discussion on pest management options may appear fairly extensive and complete I would like to stress that it must be viewed as being of limited scope and representativeness and that caution must be used when applying its findings.

There are several reasons for this. First, nursery setup and management show high variability. No two nurseries are exactly alike. In other words there is no standard nursery setup or management to make comparisons and recommendations by. This will limit the usefulness of any general observations or recommendations as any observations and recommendations which apply in the case of some nurseries would not or would only partially apply in others. Personal judgment will have to come into play when dealing with pest problems in any particular nursery.

Second, each visit to a nursery consists of a one-day snapshot in the course of a season's seedling growth and pest problem developments. Although the piecing together of all the nursery visits made throughout the duration of this assignment may provide some kind of an overall picture and definition of general patterns as to the evolution of pest problems through time, it may not accurately reflect past and future events at any of the nursery sites nor even within their respective geographical areas. Some of the reasons for this involve a complex of factors among which differing nursery management skill levels, differing geoclimates and changing weather patterns, and the effect of the alternance of dry and wet seasons on pest and natural enemies populations, may be cited. For instance weather developments or changes in populations of natural enemies may help suppress a pest problem that looked serious at one point in time in the season, thereby obviating the need for any control action, or may, conversely, aggravate it. A study of the seasonal abundance of insect pests or severity and prevelence of plant diseases in any or all of the nurseries or regions of Haïti is, in other words, what the present study is not.

This above-mentioned limitations must be borne in mind when interpreting the results of this study.

This document is divided into four major parts and five appendices. The first two parts describe the results of the plant disease and insect pest surveys, respectively. The third part discusses IPM in the context of the agroforestry tree nursery as applies to the humid tropics, the socio-economic conditions of nursery keeping, and reforestation objectives. The fourth part attempts to draw overall general conclusions and proposes general recommendations in relation to pest management in the AOP's nurseries.

Appendix I is a compendium of nursery diseases and insect pests describing symptoms, damages, epidemiology, life cycle and methods of control for the major pests encountered during this survey. This compendium takes the form of pest info sheets, displaying key information into quick reference sections in an easy-to-read two-column layout format. These pest info sheets thus constitute pest management reference material that could be inserted in the nurserymen's Nursery Care Manual. All the figures that are referred to in the report and pest info sheets are found in this appendix.

Appendices II and III represent surveys not comprised in my original scope of work which I was asked to carry out once in Haïti. Appendix II is a cursory examination of post-harvest insect pest problems in stored logs of some of the AOP's tree species made at the request of Jerry Grosenik, U. of Maine. The second assessment, requested by Dean Treadwell USAID/H, is a preliminary pest survey of peasants' agricultural crops in the Maissade Watershed Management Project and an evaluation of further assessment and research needs.

Appendices IV and V are my itinerary and list of major contacts in Haïti, respectively.

PART I.

PLANT DISEASE SURVEY AND MANAGEMENT OPTIONS

A. INTRODUCTION

This survey indicates that, during the 1987 spring production season, diseases took the largest toll in terms of seedling mortality and unthriftiness. They also are the enemies against which nurserymen feel most helpless because of their invisibility and rapidity of development. All nurserymen see are seedlings suddenly collapsing or leaf spots appearing on leaves and devastatingly blighting whole seedlings in a matter of days. As the cause or agent of this devastating loss is not immediately apparent to them, as would most fair-sized insect pests, nurserymen will often show helplessness and choose to do nothing, attributing their misfortune to something they can't be blamed for such as "bad seed" or to improper nursery management such as "bad watering", which they know has a direct bearing on a seedling's well-being. In the latter case the nurseryman may try to correct the situation by watering less or watering more which may only aggravate the disease problem, either by favouring disease development or by harming seedling growth and development thereby making it susceptible to further disease attack and progress. In the rare cases where a nurseryman knows or suspects a disease is at work he may often not know which chemical and how much to use and how many sprays to apply. Here again, the chosen action option will often be no action.

The following chapter lists all major diseases that were encountered in the nursery setting. They are discussed by categories for convenience. There are the diseases caused by environmental factors, those caused by fungi, by viruses, and by nematodes. Damage caused by slugs and snails, although these are animal pests and not diseases, is discussed under this chapter because development and outbreaks are basically favoured by the same environmental conditions as for diseases. This part closes with a list of nursery disease management recommendations.

B. PLANT DISEASE SURVEY

1. Diseases Caused by Environmental Factors

Environmental factors are often overlooked as causative agents of plant diseases and are certainly not given the same attention as biotic disease-causing organisms. They are, however, a group of diseases which can easily be mistaken for one or another disease caused by a wide range of pathogens. Environmentally-caused diseases therefore deserve detailed description and incidence accounts if only to prevent the application of wrong remedial actions such as pesticide sprays.

Several environmental factors were observed to cause seedling unthriftiness as well as appreciable mortality in AOP's nurseries. These are moisture, light, mineral deficiencies, herbicide injury, transplanting injury, grafting injury, and fertilisation.

a) Moisture

In addition to being an important factor contributing to disease development, water alone can, if improperly applied, cause seedling mortality and unthriftiness. Two types of moisture stress can occur in the nursery context: underwatering and overwatering.

Underwatering and overwatering of seedlings, and sometimes a combination of both, were observed at many nursery sites throughout the country. I would contend here that these cause more damage than meets the eye. Proper watering management has been constantly stressed right from the AOP's onset through the production of a Nursery Care Manual and through training seminars. Yet few nurserymen appear to understand how crucial carrying this task out properly really is. Only a well-trained and perceptive nurseryman can detect at a glimpse water deficiency or water logging and forecast watering needs on a species per species and day by day basis. Tree species are likely to assimilate water at differing rates depending on the soil mixture in which they grow, their growth stage and rate, the amount of shading received from the neighbouring light-competing seedlings and from the nursery shading cover, and their general health status. Weather changes also affect watering needs. A bright sunny day will generate a lot of photosynthetic activity and will therefore cause seedlings to use up more water through evapotranspiration. A cloudy day will have just the opposite effect. And of course several rainy days in a row might just jeopardize a carefully monitored watering schedule. Water shortage too, can be a crucial problem. Only one nursery reportedly experienced an acute water shortage this season. The nursery manager then chose to restrict his production to one species and to utilising one third of the total available nursery space only, in order to economize water and to allow him to keep his nursery personnel on. The unfortunate and ironic result was that seedlings were badly overwatered (causing 30% loss to damping off at the time of appraisal) by nursery personnel trying to keep themselves busy.

Underwatering symptoms take the form of arrested growth and, in extreme cases, of leaf drooping and plant wilt. Symptoms of underwatering in Chadek in one nursery took the form of retarded growth and papery-textured and mottled chlorotic leaves, with the leaves finally rolling up and falling off. Additional examination of root plugs should reveal bone dry grow mix in the bottom half to two-thirds of the plug with only the top one inch receiving appropriate moisture (see Fig. 1 & 2).

Overwatering was found to be much more common and generally involved slow-to-arrested growth and undeveloped, although otherwise healthy, root systems. Signs of overwatering include green algal growth over the soil surface and the presence of fungus gnats. Fungus gnats are *not* parasitic insects (except for very few species) and will feed on rotting plant debris and roots.

b) Light

Both a lack or an excess of light can cause plant damage. Lack of light promotes spindly growth (etiolated plants) and thinner leaves. This occurs under conditions of overshading and/or overcrowding, where competition for the available light is intense. Species also show differential responses to shading. That is the case for *Citrus* spp. which should be removed from shade much sooner or even never given any shade for fear of obtaining very thin leaves. Etiolated plants with thin leaves are more susceptible to chemical damage (fertilizer or pesticide) and to attack by diseases and insect pests.

Damage caused by an excess of light first appears as water-soaked leaves, which later turn scorched. Sunburn occurs when seedlings are suddenly withdrawn from shade and put in full sun or when plants are water-stressed prior to sun exposure or when watering is not adjusted to compensate for increased evapotranspiration and photosynthetic activity of seedlings once put out in the sun. Sunburn damage was observed in one nursery on Cassia seedlings which had just been moved to under a metal shed (!) for protection, so sudden and severe had sunburn been following placement in the sun. In this case the problem was compounded by fairly acute underwatering.

c) Nutritional Deficiencies

Several nutritional deficiencies were observed, especially on seedlings grown in locally made or bagasse-based soil mixes.

The forest tree species most affected were Chen and Bois capab which showed a fairly pronounced nitrogen deficiency with leaves light green in colour.

The fruit tree and cash crop nursery stocks with highest mineral deficiency prevalence were the *Citrus* spp. (fig. 3) and mango, and coffee, respectively. This is probably because these are frequently grown in large black plastic bags which nurserymen routinely fill with local soil mixes so as to purposely avoid the high cost of filling larger containers with imported mixes. Symptoms of nutrient deficiencies among plants within lots were highly variable, from faint or no symptoms to marked and varied (which could be an indication of poor soil mixing). The deficiencies included: Nitrogen, leaves are pale green in colour; Phosporus, dark bluish-green leaves; Iron, young leaves severely chlorotic with main veins remaining characteristically green; Zinc, leaves show interveinal chlorosis and are few and small, internodes are short and shoots form rosettes. Other nutrient deficiencies, particularly micronutrient deficiencies, might be involved but those mentioned here were the most striking and conspicuous.

d) Herbicide Injury

In one fruit tree nursery symptoms of herbicide injury (faintly mottled and chlorotic leaves) were observed on mature *Citrus* trees growing in the midst of the nursery but not on the nursery stock. I suspect the nursery site was sprayed before the start of the season or with the stock put away. Upon investigation it was found that the nurseryman had sprayed with glyphosate (Roundup).

e) Root Injury due to Transplanting

Most nurseries practice transplanting of young seedlings for the purpose of filling Rootrainer cells left empty by seedlings that died of disease or which did not germinate. The seedlings for transplanting are either taken from adjoining rootrainer cells which contain more than one germinated and healthy seedling (overseeding will ensure this) or from a backup seedbed. Very few nurseries make a general policy of transplanting all tree stocks. Most transplant some species and direct seed others. Whether transplanting is carried out as a general policy or as a back up generally depends on how poor germination or seedling survival is and on how difficult it is to handle the seed, in the case of direct sowing.

Regardless of the purpose, transplanting has been found to take a large toll in terms of seedling mortality. Important damage is often done to the young roots, sometimes beyond repair, which cause the seedling to wilt and dry up in a matter of a few days. Root damage also facilitates attack by soil-borne pathogens such as *Pythium* spp. and *Phytophtora* spp., which cause damping off and root rot diseases, as well as to saprophitic soil fungi which in normal situations would not be able to attack healthy roots and become pathogenic.

Another inconspicuous but pervasive damage caused by transplanting is the the formation of "J" roots, that is, the folding back of the main root over itself as the seedling is driven into the cell. This causes delayed growth and very often irremediably cripples seedlings.

My attention was drawn to the fact that Casuarina is a species that will generally not stand transplanting. However, some nurseries claim fair success with transplanting Casuarina.

f) Shoot Injury due to Grafting

Grafting of fruit trees such as *Citrus* spp. and Mango (*Mangifera indica*) is done in some of the Project's fruit tree nurseries. In the case of mango the graft is a 10 to 20 cm long shoot which is wedge-grafted into the cut-off top portion of the rootstock. Grafting momentarily arrests shoot growth, which causes the youngest leaf's sheath to dry up, while still wrapped up around the leaf. When growth resumes, breaking open the hardened sheath damages the young leaf which then appears smaller, crippled, and rough textured. Anthracnose (*Glomerella cingulata*), a weak pathogen which can only infect previously injured plant tissues, will often attack the young mango leaves damaged in this way, thereby causing secondary infection. If well done, the graft will usually recover in time to permit resumption of shoot growth and of normal leaf shape and appearance by the time subsequent leaves emerge. In severe cases, however, all the leaves may be shed, with the graft sometimes recovering, but only after an extended period of arrested growth.

g) Fertilization

Overfertilization promotes succulent growth which in turn attracts insect pests. In one nursery, the *Citrus* aphid, which only becomes a problem when flush or succulent growth is produced, was observed on succulent growth promoted by heavy fertilization.

2. Diseases Caused by Fungi

This is the most important group of diseases encountered in the agroforestry nursery setting in Haïti. Fungi diseases have been grouped by type of symptoms, for convenience. These are the Damping Off and Root Rot diseases, the Sooty Molds, the Powdery Mildews, and the Leaf Spot diseases.

a) Damping Off and Root Rot Diseases

Damping off and root rot diseases are generally caused by *Pythium* and *Phytophtora* spp. and others and are generally widely prevalent in soils and water of the temperate and tropical countries.

Pre-emergence and post-emergence damping off were highly prevalent throughout the nursery sites and were causing low (5-10%) to moderate (20 to 50%) and occasionally high (about 80%) losses, with Casuarina, Leucaena, and Mahogany being the most affected species. *Rhizoctonia*, which was isolated from infected Casuarina seedling roots last year by plant pathologists at the U. of Florida (see R. S. Webb's letter to R. Wilson), was found to cause 5% mortality of Casuarina seedlings in some instances (see fig. 6).

These loss figures were obtained by selecting 5 racks at random and counting the number of empty cells and cells containing infected seedlings out of a total of from 160 to 240 cells, within a delimited section. However, a true evaluation of losses would have to take germination success and extent of transplantation into account. This proved to be difficult as germination tests are not routinely carried out and transplantation is an *ad hoc* practice, repeated several times throughout the season with the number of seedlings transplanted not being logged by the nurseryman. In the only documentable case I have come across, Leucaena seeds with a germination test of 65% produced only 10-20% germination in the racks, even though each cell had been overseeded by a factor of two to three. Examination of seeds dug out of root plugs revealed rotting characteristic of pre-germination damping off.

It is my belief that the poor stands commonly observed in nurseries are largely due to pre-germination damping off and *not* to poor germination, as commonly believed by nurserymen and regional managers and foresters. In only one instance could I identify with certainty poor germination as the cause of a poor stand.

Damping off was most severe in nurseries where overwatering was a problem and/or where overcrowding and poor air circulation prevailed and/or where unsterilized and poorly drained soil mixes were used. Overwatering promotes germination and movement of spores of water molds and maintains an environment favourable to disease attack. High seedling densities impede air circulation and prevent wind ventilation from quickly drying the soil surface, thus creating microclimatic conditions favouring high humidity build-up within the canopy. Growing media containing a high proportion of local soil or bagasse exhibit poor drainage and high water retention (bagasse has some of the physical characteristics of heavy clay when wet), and are therefore prone to become water logged and to impede growth and promote disease development.

Weeds may also promote damping off. I have observed that even supposedly sterile mixes such as Fafard's Grow Mix contain weed seeds which germinate in the Rootrainer cells and quickly outgrow the tree seedlings, thereby impeding air circulation and creating microclimatic conditions favourable to disease development. Vegetation growing within and around the nursery may also, if not removed, impede proper air circulation, especially if the racks are low to the ground (fig. 8 & 11 & 12). Tall tree hedgerows delimiting nursery sites also play a role in disease development in that they reduce wind ventilation and shade the nursery, creating microclimatic conditions favourable to disease development within close range of the hedgerow. In one instance, foliar and root rot diseases were actually observed to be more prevalent in racks closest to hedgerows.

The use of clean water is also a major factor in preventing damping off diseases. Since damping off and root rot diseases are water molds, river and source waters will often be contaminated with their motile zoospores. Most nurseries rely on river or source water for irrigation. Exceptionally, one nursery recycled its catchment irrigation water for re-irrigation because of an acute water shortage. This constitutes an excellent means of spreading soil-borne diseases. Although the nursery manager did recognize these facts, he advocated that he had no choice.

Damping off problems will also arise as a consequence of nursery practices such as transplanting and deep placement of the seed in the cell. Placing the seed too deep in the soil strains a young germinating seedling as it must expend more energy and oppose more resistance to push its way up, with the ensuing consequence that it is exposed for a longer period of time to attack by soil-borne fungi. Transplanting damages and breaks roots thereby providing ports of entry to pathogenic as well as saprophitic fungi. The likelihood of infection will of course be higher when transplanting is done in cells left empty by seedlings that died of damping off. In addition, the seedlings for transplanting are often grown in seedbeds which rest directly on the soil surface. Seedlings' roots can, in this way, be expected to grow into the soil and pick up injurious fungi, bacteria, and nematodes, even prior to transplantation.

Another factor which favours damping off is the high variability in the rate and success of seed germination. Very uneven stands were often observed which were due to very slow seed germination. Very slow germination exposes germinating seedlings for a longer period of time to attack by soil-borne fungi.

Since Rootrainers are reused from season to season it is recommended that they be washed and sterilized so as to eliminate spore carry over. This recommendation is hardly observed in practice and in the few rare cases where I was told Rootrainers had been sterilized, I found out it had not been done properly. Nurserymen admitted to have simply placed the empty Rootrainers in the racks and to have washed them down with a Chlorox solution which, in addition, was in all probabilities too weak. For sterilization to be effective, Rootrainers have to be *soaked* in the Chlorox solution for at least 20 to 30 minutes. This survey also indicates that solarization of Rootrainers is also, although used much less commonly, employed as a means of sterilization. Although this is a valid method, its effectiveness remains to be tested in Haïti's field condition. A disadvantage of solarization is that it increases brittleness and thereby drastically shortens the life expectancy of the Rootrainers which nurserymen complain is already too short.

Dressing of seeds with an appropriate fungicide such as Captan was reported as having been carried out in only one or two nurseries. One nurseryman would put Captan in the soil before mixing. Spraying as a remedial intervention once the disease has appeared is apparently infrequently carried out and when it is, it is probably carried out too late as action is taken only when a large proportion of the attacked seedlings already show irremediable signs of advanced infection.

b) Sooty Molds

Sooty molds have been observed on *Citrus* spp. (fig. 13,14,15) and Leucaena (fig. 42). Sooty molds are saprophitic fungi which grow on the honeydew exudates of sap-sucking insects such as aphids, mealybugs, scales, and psyllids. The fungus itself will not cause any damage to the plant unless it coats the leaves so thickly as to cause a decrease in photosynthesis. It is, however, a sure sign of an insect infestation requiring immediate attention.

The insects present on *Citrus* spp. were scales (fig. 15) and on Leucaena, psyllids (*Heteropsylla cubana*).

c) Powdery Mildews

Powdery mildews (*Oidium* spp.) were found on *Eucalyptus camaldulensis, Cassia siamea, Acacia auriculiformis* (fig. 16), *Casuarina equisetifolia*, and on *Carica papaya* (fig. 17 & 18) in all regions of the country but in the South. Disease incidence in all instances was quite high (> 80% seedlings showing symptoms) although no extensive damage was to be seen yet. The exception was Casuarina in one instance which showed 100% disease incidence and 20-30% die-back at the time of appraisal.

The reason why powdery mildews were observed everywhere but in the South may be due to the fact that shading was still on in all nurseries visited except for those in the South. Powdery mildews develop best during the driest but coolest period of the year. Heavy rains of long duration which maintain leaf wetness for prolonged periods and bright, sunny, hot weather are unfavourable to the disease. I contend that shading, if unduly maintained for a prolonged period of time, provides just those conditions which promote fungus development and spread.

Tiny, black, sunken spots radiating in a water drop splash pattern were observed on the leaves of Cassia grown in many nurseries in the South(fig. 19 & 20). These damage symptoms may be the result of the suppression of the fungus by the sun shortly after shade removal. The fungus is an ectoparasite which means that its mycelium grows on the surface of the leaf, as opposed to most fungi whose mycelium develop internally, and that nourishment is drawn from infection pegs sent down into individual cells. I suspect that those tiny necrotic spots are the cells which were infected by the fungus which concurrently died with exposure to the sun, producing symptoms much like those of a hypersensitive reaction whereby a cell undertakes desintegration and dies upon infection in order to prevent further invasion by a pathogen. However, Kranz *et al.* (1977) have described similar symptoms caused by *Glomerella cingulata* (Anthracnose) on mango, as being very small brown or black spots which are a non developing latent form of the disease and are either isolated or grouped in a tear-stain pattern, which is evidence of the distribution of spores in dew drops. Whether the first or the second hypothesis should be retained to explain the cause of those symptoms would require observation of whether the foliar spots expand with time (which is evidence of a pathogen invading more healthy tissue) and attempts at isolating a pathogen.

d) Leaf Spots

Leaf spot diseases were numerous but mostly of the Cercospora type. They were mostly observed on Cassia where the disease caused from 40 to 100% losses when present (fig. 21 to 26).

In one instance there was fairly severe Cercospora damage on Neem (*Azadirachta indica*) (fig. 28 to 31) causing approximately 20% loss and on *Acacia auriculiformis* (fig. 32 & 33), causing nearly 35% loss. Incidentally, this nursery also experienced a 100% loss of Cassia to Cercospora (fig. 27). In this case Cercospora diseases seemed to be most severe due to high plant density and the seedlings' advanced stage of development.

Cercospora coffeicola (fig. 34) was also observed on coffee but was not causing any extensive damage at the time of appraisal.

A similar disease occurs on *Citrus* spp. causing wither-tip and die-back symptoms (fig. 35 & 36) which I believe are due to anthracnose. Loss here was in the neighbourhood of 20% at the time of appraisal.

Anthracnose was also observed on 100% of emerging Neem seedlings in one instance. The seedlings were covered with the characteristic sunken necrotic lesions of the disease right upon seedling's emergence which constitutes definite evidence of the seed-borne nature of the disease. I doubt these seedlings would survive.

Cercospora and anthracnose diseases can be borne in or on the seed from which primary infection occurs and may cause further losses through secondary infection, that is through the spread of spores from necrotic lesions to healthy plant tissues.

3. Diseases Caused by Viruses

Only in one instance were virus diseases noted. Losses ranged from 5% in the case of Ced (fig. 38) and Chen (fig. 37) to 85% in the case of Bois capab (fig. 37). Unfortunately an insectide had recently been applied so that it was difficult to verify whether the virus disease had been vectored. Nevertheless a few black aphids (most likely the Citrus Aphid, *Toxoptera aurantii* (see mite damage fig. 40) were found on Chen as well as mites on Ced. The Citrus aphid is the vector of the virus causing Tristeza (Die-back) Disease of *Citrus* spp., and other viruses. A few mite species are known to transmit viruses but I don't think this was the case here since the few seedlings on which the mites were found, although heavily infested, did not show symptoms of viral disease. The virus could also be seed-borne but I would doubt it since the symptoms developed in foci within the racks thereby denoting the short distance movements of insects such as aphids. The evidence suggests that aphids transmit the disease but that the insecticide application wiped them out.

4. Diseases Caused by Nematodes

Nematodes were a problem in Chadek (fig. 41) in one instance only, but where they caused so much unthriftiness and mortality that the nurseryman had given up on them and had relegated them to a corner of the nursery site where he was gradually neglecting their watering, thus compounding the problem further. Unfortunately I was not able to have access to laboratory facilities in time to allow me to extract the nematodes from the soil and identify the species.

Nematodes were also encountered in Leucaena in another nursery but were not causing any apparent damage then.

Nematodes were a problem because the nurseries where nematodes were found all happened to use unsterilized local soil in their growing medium.

In normal circumstances, i.e. when a sterilized mix is used, nematodes should not be of concern.

5. Pest Slugs and Snails

Slugs and snails were found to cause damage in one fruit tree nursery. Damage was not extensive but this is probably because populations were kept in check with repeated applications of granular formaldehyde 5%.

This slug and snail problem was self-induced in that the common practice of stacking the plastic bags used as containers against each other (they do not stand well on their own) provides a highly humid and sheltered environment that is favourable to the breeding and development of those animals.

This problem should resolve by providing good air circulation through spacing out of the potting mix bags.

C. DISEASE MANAGEMENT RECOMMENDATIONS

Recommendation # 1: That seed germination tests be carried out at seeding time to help determine to what extent poor stands are due to pre-germination damping off and whether corrective measures should be taken.

Recommendation # 2: Water on demand, *not* on schedule. If one sees algal growth or fungus gnats, this means overwatering. Allow soil surface to dry out in between waterings. Check plugs to ensure soil is moistened throughout. Water preferably in the morning as to prevent excess moisture on soil surface and leaves.

Recommendation # 3: Provide good air circulation around the seedlings. As a rule of thumb, space out seedlings every time the canopy closes in so as to avoid creating microclimatic conditions suitable for disease development. Spacing out of tree species grown in plastic bags which can't be managed to stand upright can be accomplished by placing them in stretched Chrysantemum wire grids of the type used by florists to support tall stem flowers.

Recommendation # 4: Avoid planting hedgerows of tall trees around the nursery. They prevent the wind from providing sufficient air circulation around the seedlings and create microclimatic conditions favourable to disease development within their immediate vicinity.

Recommendation # 5: Choose nursery sites that permit optimum exposure to wind. Avoid low-lying and sheltered sites with still air, and that can become flooded during heavy rains.

Recommendation # 6: Do not use white-washed plastic as shading cover as it impedes proper ventilation and increases relative humidity. Use of black shading cloth or dried palm leaves is recommended as these do not retain excess humidity and can easily be removed for a few hours and replaced daily for the purpose of acclimatizating seedlings to sunlight.

Recommendation # 7: Do not overshade or otherwise unduly prolong the shading period as this results in the production of etiolated plants and thinner leaves which are more susceptible to insect and disease attack and to chemical damage. Decide on the amount of shading to provide on a species basis e.g. *Citrus* spp. require very little or no shade at all.

Recommendation # 8: To avoid sunburn damage, acclimatize plants by removing shade for only one hour the first few days, for two hours the next few days, for three hours the following next few days, and so on until the seedlings are deemed to be hardened enough to withstand full time sun exposure.

Recommendation # 9: Leave shading only for as long as protection of seedlings from the sun is deemed necessary. The sooner shading is removed the less time powdery mildews have for infection and development.

Recommendation # 10: Keep Rootrainer cells and nursery site free from weeds and alien vegetation as these may create conditions favourable for disease development, and provide alternate hosts for insect pests and pathogens, as well as shelter for rodents. Compare clean (fig. 9 & 10) to untidy (fig. 8 & 11 & 12) nursery sites.

Recommendation # 11: Do not spray herbicides around the nursery as the spray drift may damage nursery stock. You may, however, apply granular herbicides.

Recommendation # 12: Raise racks at least 0.5 to 1 meter above ground to allow better air circulation (fig. 8 & 9 show improper and proper setups, respectively). This will also facilitate chores such as weeding, transplanting, and spacing out.

Recommendation # 13: Do not use wooden racks as these may decay from wood-rotting fungi that may also attack living trees.

Recommendation # 14: Do not plant the same tree species grown as nursery stock around or within the nursery for beautification or demonstration purposes as these can provide a host continuum for insect pests and diseases during the nurseries' off-seasons and a reservoir of infestation during the growing season.

Recommendation # 15: Use only sterile growing media since unsterilized soil may contain pathogenic fungi, bacteria, and nematodes. As pressure mounts, for economic reasons, to using local growth mixes such as the Haïti Grow Mix, I recommend that those be tested and certified free of harmful organisms (including weeds) before they are recommended widely for use. Use of local soil, even if sterilized, is discouraged as it doesn't make sense to strip this country of what little top soil it has left.

Recommendation # 16: Clean and sterilize containers by soaking in a 2% formalin solution or a Chlorox solution for at least 20-30 minutes and preferably for a few hours. Do not simply hose down containers laid out on racks as appears to be commonly done. Oil drums or other large containers would suit this purpose.

Recommendation # 17: Use water free of spores of parasitic fungi such as water molds (Damping Off and Root Rot diseases). River and source waters will very likely be contaminated and carry such spores. Use deep well or rain water whenever possible. Do not wash plant material or tools in the water reservoirs as these are apt to carry contaminated soil. Do *not* use catchment irrigation water to re-irrigate the nursery.

Recommendation # 18: Do not sow seeds too deep. As a rule of thumb, cover seed with no more than 2-3 times its thickness in soil.

Recommendation # 19: Dress seeds with Captan, Thiram, Ferbam, or any other suitable fungicide (check compatibility with inocula, when applicable). Mixing Captan with the soil is not recommended as soil particles may bind or deactivate it; it may also be leached out with the first few waterings. You want the fungicide where it is needed, that is right in the seed sphere, and you also want the extended effectiveness provided by proper dressing techniques and mixtures.

Recommendation # 20: To avoid transplanting shock and damage, transplant seedlings when they are very young, that is when these bear at most 2 to 3 leaves, or transfer whole plugs into empty cells, taking care not to disturb the root system. The latter option is preferable, especially if the recipient cell previously contained a seed or seedling that died of damping off but also because a more even stand may be obtained in this way. If seeding the back-ups into a seedbed, use an above ground seedbed filled with sterile medium and devoid of any contact with the soil. When transplanting keep species together. If back-up seedlings of the same species are not available for transplanting, condense the remaining seedlings into fewer racks instead of intertransplanting mixed species (see fig. 27). This will help regulate watering and pesticide applications better, and to keep track of stocks and of any problem that might appear, on a species per species basis.

Recommendation # 21: When grafting mango trees, leave only a few leaves on the grafted shoot to permit faster graft taking and growth resumption. If first leaf to come out after grafting appears damaged, remove and burn it.

Recommendation # 22: Cull and burn diseased or withered seedlings. This task can be simultaneously carried out with weeding.

Recommendation # 23: Collect seeds from healthy trees so as to avoid the spread of seed-borne diseases. Establishment of a seed certification program might be in order here for the distribution of seeds which have a high germination rate and success and which are disease-free, and for providing a standard and uniform seed quality that can be relied upon from season to season. Using fast germinating seed reduces the critical phase of germination and emergence and therefore helps avoiding losses due to damping off diseases.

Recommendation # 24: Keep an accurate record of all nursery operations and of seed provenance. This will help reconstruct scenarios should problems occur.

Recommendation # 25: When more than 5% of the germinated seedlings show damage to damping off, apply fungicidal treatment (Ziram, Chloranil, Captan, etc.) at once and repeat at 4-5 day intervals until plants have passed susceptible stage or disease is no longer a problem. Or apply a soil drench with Captan.

PART II.

INSECT PEST SURVEY AND MANAGEMENT OPTIONS

A. INTRODUCTION

Insect pest problems were not as numerous and damaging as were plant diseases; with a few exceptions. Attention is drawn to scale insects which can quickly infest *Citrus* spp. and cause serious damage; to aphids which can vector virus diseases; to psyllids which pose a significant threat to Leucaena outplantings but that can easily be controlled in the nursery; and to the Bean Seed Maggot which causes high losses in Saman.

Perhaps one of the reasons for fewer insect pest problems than expected is the usually high visibility of damage caused by insects such as leaf-eating caterpillars which has the nurseryman reach out for his spraying equipment at first sight and blanket spray his whole nursery. This practice will of course take care of many other insect pest problems that might have happened to be there at the same time, whether or not they were causing significant damage. Most nurseries visited had already received from one to three insecticide applications since the beginning of the season. It is therefore hard to affirm or confirm, in such a situation, whether the control of many of the pest species encountered is justified and whether this survey is a thorough representation of the insect pest scene in the agroforestry nursery context.

The next chapter discusses the nature and the extent of the insect pest problems by insect type and the last chapter lists insect pest management recommendations.

B. INSECT PEST SURVEY

1. Homoptera (Psyllids, Aphids and Scale Insects)

a) Psyllids or Jumping Plant Lice

Psyllids (*Heterospylla cubana*) were encountered in all nurseries where Leucaena or Saman are grown, throughout the country. In only two instances was the psyllid infestation moderate to high, with some seedling die-back appearing at the time of appraisal (fig. 42). Low psyllid infestations in other nurseries might be the result of frequent spraying for other insect pest problems such as aphids and caterpillars.

Psyllid damage is less conspicuous than caterpillar damage, but may not be recognized, if spotted at all, as an insect pest problem by nurserymen. It can in fact be mistaken for a disease problem when sooty molds develop on the honeydew exudates of the psyllids, giving the leaves a black smutted appearance. The nymphs themselves are very small and can easily be mistaken for aphids when detected. The adults can be seen jumping around in reflected light when the foliage is disturbed by either splashing irrigation water or handling of seedlings.

Although psyllids can easily be controlled with insecticides in the nursery context, I would like to alert AID, PADF, and CARE to the threats it poses. First, insecticide resistance might be expected to show up very rapidly, should chemical control become the preferred method of control, as this insect has a very high reproduction rate and capacity. Second, I have seen no natural enemies at work that could keep psyllid infestations at bay. In all my samplings, I only caught one spider that could have been predating on the psyllids and did not observe emergence of parasites from psyllid-infested Leucaena shoots kept in plastic bags. Third, this insect is currently threathening to wipe out all the Leucaena plantations of the Philippines where it completely defoliated mature trees by the end of 1985, the very first year it was noticed. Psyllids were reported to be present on the newly produced shoots at the beginning of the following growing season immediately after in 1986. Due to lack of further reports and suddenness of outbreak, it is not known whether the Leucaena trees in the Philippines might eventually succumb to repeated psyllid attacks in the near distant future should no control, particularly chemical control, be attempted. Supposing the infestation is brought under control and trees can recover, this will nonetheless mean several lost years in terms of growth opportunity and possible physical tree misdevelopment, which immediately translates into dollar losses, without mentioning the millions of dollars spent in research and control.

Driving alongside country roads I could see mature Leucaena trees showing symptoms of high psyllid infestation as shoots coated with sooty mold. It has been reported that biological control, specially by the ladybird beetle *Curinus coeruleus*, is effective and outstanding in the Caribbeans (NFT Highlights, February 1986). Agronomists working at the Faculte d'Agriculture et de Medecine Veterinaire in Damien and the field agronomists and foresters working with AID, PADF, and CARE seem to also believe that this is true of the field situation in Haïti. Some agronomists have observed that the psyllid problem is always apparent during the dry season but that it disappears come the first few heavy rains. Observations made in the Philippines (John Borden, pers. comm.) indicate that psyllids are as numerous during the rainy season as the during the dry season. The difference is that well watered trees are better able to withstand attack and appear as if the psyllids were gone, whereas during the dry season, water stress combined with a psyllid infestation can cause drastic defoliation.

Whether the insect's population growth and damage are limited by natural enemies or by cyclical weather patterns, or whether the insect population is limited at all and is just waiting until a higher population density of Leucaena trees be reached throughout the country before exploding and ruining years of reforestation efforts, remains to be confirmed either by observation or by rigourously planned research. The stakes are high, as examplified by the Philippino peasants who do not want to replant Leucaena trees even if they are told the newer varieties are resistant to psyllid attack; so much destruction has been sudden and devastating, both in the field and in their minds (John Borden, pers. comm.).

Research is underway in the Philippines in the areas of chemical control, biological control by natural and imported enemies, and resistance breeding. See the Pest Info Sheets, Appendix I, for more details.

b) Aphids

The Citrus aphid was found on *Citrus* spp. and is also thought to have vectored a virus disease on Bois capab causing 85% seedling mortality in one instance. In both cases infestation was low probably owing to previous insecticide applications. On *Citrus*, the insect was seen feeding on succulent growth, probably caused by overfertilization.

Another, seemingly common, species of aphid was found on several other tree species but mostly on Chen (*Catalpa longissima*). Although more abundant they did not seem to cause extensive damage at the time of appraisal nor did they appear to transmit virus diseases. Overshading seemed to be partly responsible for the infestation, as the seedlings harboured thin soft leaves. Aphids were not noticed on seedlings growing in full sun. Precise identification was not attempted due to the probable commonness and fortuitous presence of the insect.

No predation was ever noticed but a few aphids were found parasitized (aphid is still and has a swollen body which is pinkish to brownish in colour; sometimes an exit hole can be seen at the posterior end of the empty aphid's carcass through which the parasite emerged).

c) Scale Insects

Several species of scale insects were found on *Citrus* spp., particularly important species being the Cottony Cushion Scale, *Icerya purchasi* Mask., the Citrus Snow Scale, *Unaspis citri* and a soft scale species, unindentified as yet.

A low infestation of the Cottony Cushion Scale was found in one nursery but was showing signs of increase as many young crawlers were present under the mothers' characteristic white, fluted egg-sacs. The scales were actively tended by ants and therefore no predators were to be seen.

The Citrus Snow Scale was found feeding in high numbers on one of the main limbs of a mature *Citrus* tree (fig. 43 & 44) growing in the midst of a nursery, but not on the nursery stock itself. This constitutes a typical example of what I have repeatedly seen through my visits to nurseries: the same species that are grown in the nursery as seedlings are found growing as mature trees right within or around the nursery, probably for the purpose of beautification or demonstration. Those trees act as reservoirs of infestation, with insect pests ready to reinvade nursery stock after sprays, and as host continuum for when the nurseries are deprived of stock during the off-season (see also fig. 45 for another example).

The Citrus Snow Scale usually infests woody portions of trees such as the trunk and the main scaffolding limbs and may completely kill limbs and branches, and if the infestation is severe, the whole tree. This species has no known effective natural enemies in Florida and petroleum oil sprays are very ineffective against it; chemical control with azinphos (Guthion), malathion, diazinon, carbophenothion, or ethion combined with oil is recommended.

The last species of importance was a soft scale found in yet another nursery. Infestation was high as evidenced by the extensive covering of all leaves by sooty molds. This species will have to await identification before it can be more extensively discussed.

2. Lepidoptera (Caterpillars)

Only one species of caterpillar, as yet unidentified, was found feeding on several nursery species, notably *Citrus* spp. and Cassia. The same species was found feeding on corn (*Zea mays*) during a visit to an outplanted fruit tree grove. It showed feeding damage similar to that caused by caterpillars of the Pyralidae family. Complete identification is pending upon rearing the adult moths from live caterpillars. This could be carried out during a subsequent survey or assignment.

I contend that this species is an opportunistic species, which may feed preferentially on corn but which is found attacking much less preferred host species when under high population pressure and when its preferred host is grown nearby on vast expanses of land. Maize happens to be extensively grown in the North-West Peninsula of Haïti where this caterpillar was found.

Further studies would be necessary to determine the pest status of this caterpillar and whether insecticide applications against it have been justified in the past or may be justified in some years.

Based on the fact that I could find only very little damage caused by caterpillars and very few larvae in most nurseries it appears that nurserymen may be applying insecticide sprays unnecessarily, when caterpillar densities or damage do not justify it, or may be applying them too early, when very few eggs have yet been laid or hatched, and while the infestation peak is yet to come.

3. Diptera (Maggot Flies)

A seed maggot, tentatively identified as the Corn Seed Maggot or Bean Seed Fly, *Hylemya platura* (Meig), was found causing over 80% losses in Saman in the nurseries of the North-West Peninsula, which happens to be the only region in which Saman was grown this season. The pest could well be distributed country-wide and could cause damage wherever its host might happen to be grown.

The Bean Seed Fly attacks seeds and seedlings of beans and maize. The ovipositing females are attracted to freshly disturbed soil. Maggots bore into the cotyledons of sown seeds and eat them out, often while the seed is germinating up until the cotyledons have emerged above ground. The cotyledons never open and the shoot never develops. Eventually the cotyledons turn into a loose mass of frass and wither away. Seedlings that have escaped damage at that point may still be attacked until the first few leaves are fully expanded, in which case the maggots bore right into the soft stem and cause the seedling to fall over and eventually wither.

Control can be effectively achieved by dressing seeds with an appropriate insecticide. However, given the small scale of nurseries, I suggest a physical method of control could be used instead of or in conjunction with seed dressing, which would consist of laying a fine-meshed mosquito screen over the freshly sown Rootrainers to prevent female flies from laying eggs.

4. Hymenoptera (Ants)

Although seed-eating ants are reportedly a problem at times, I could not substantiate this claim or assess the extent of their damage as the seeding season was over by the time this insect pest and plant disease survey was initiated.

The only ant problem I have been able to assess first- hand is the tending of scales and aphids feeding on *Citrus* spp. by honeydew-harvesting ants. The ants themselves are not injurious to the plant but protect the insect pests they tend from predation. It is therefore important to control the ants as well the insect pests if the latter are to be successfully managed. One way to do this is to wrap a sticky paper or plastic band around the stem of the tree to prevent the ants from climbing up, and therefore from tending their "herds".

5. Acarina (Mites)

Mites were detected in low numbers on a few tree species, notably on Ced (*Cedrela odorata*) and Bois capab (*Columbrina arborescens*). Identification was not attempted since they did not appear to cause significant damage nor did they appear to be capable of developing high infestations. Those trees are probably non-preferred host species or highly resistant to mite attack because they support very low and patchily distributed mite populations without incurring any significant damage.

C. INSECT PEST MANAGEMENT RECOMMENDATIONS

Recommendation # 1: Do *not* plant trees of the same species that are grown in the nursery within or around the nursery itself for the purpose of beautification or demonstration, as these are apt to become reservoirs of infestation and provide a host continuum during the nurseries' off-seasons.

Recommendation # 2: Control measures against the Citrus aphid should only be applied in periods of flush or fertilizer-provoked succulent foliage, where the recommended action is spraying with dimethoate (Cygon) taking care to thoroughly wet the flush leaves.

Recommendation # 3: Control of the Cottony Cushion Scale should involve controlling the ants that tend them, when present, by wrapping a sticky paper band around the base stem, and spraying with Malathion. I do not know whether the scale's main biological control, the vedalia ladybird beetle, is present in Haïti.

Recommendation # 4: Control psyllids with Sevin, Neem extracts, or insecticidal soaps. Apply at first signs of sooty mold growth. Use soaps whenever possible since these are non-toxic to humans and do not harm natural enemies.

Recommendation # 5: Control the Bean Seed Fly problem in Saman with seed dressings of ethion, diazinon, or pirimiphos-ethyl. However care must be taken with diazinon, for higher dose rates may show marked phytotoxicity. Physically preventing the female flies from laying eggs in the soil by laying out a fine-mesh screen over the Rootrainers after seeding until germination is completed could prove an efficient and safe method of control. This method of control could also prevent alleged seed predation by rodents.

PART III.

IPM IN THE AGROFORESTRY TREE NURSERY CONTEXT

A. INTRODUCTION

I believe Integrated Pest Management constitutes a valid strategy within the Agroforestry Outreach Project tree nursery. Prime, low-cost and low-technology pest management tactics within the IPM strategy will consist of cultural practices, reliance on natural enemies and use of resistant cultivars. Pesticides, if properly used, also constitute a valid tactic, though they should be resorted to only when all else has failed. Conversely, some pest management tactics, such as classical biological control, may not be applicable due to the small scale of the project both at the nursery and at the funding levels. Likewise, the employment of high-technology such as pheromones should be discouraged because of non-sustainability of importations of such technology in Third World situations. Many control tactics can be easily integrated and adopted by blending them in the nursery's routine operations of watering, spacing and shading, to the extent that one forgets or never realizes that such operations double up as pest control practices. It is all a matter of supplying proper training initially, followed by full technical and extension support within an understanding of the socio-economic motivations of nurserymen. This is what part III will attempt to synthesize. The technical and socio-economic considerations involved are discussed in the following chapters.

B. TECHNICAL CONSIDERATIONS

1. Cultural Control

Cultural control is undoubtedly one of the choice tactics of pest control as it involves little effort and money investment and is fairly effective, although it rarely provides near perfect control and is not fail-proof. Once inserted in the day-to-day field or nursery operations, cultural control methods become an integral part of the production system and their primary purpose is quickly forgotten.

Cultural controls in the AOP nursery context encompass: proper plant watering, spacing, and shading; as well as seeding, seeding date, fertilizing, transplanting, grafting, elimination of potential reservoirs of infestation and host continuums, weeding and the use of nutritionally balanced and pest-free growing media, etc. All together, these practices constitute the foundations of a sound and efficient production system.

2. Physical Control

Physical controls are usually safe, cheap, and efficient. They might involve placing a sticky band around the base stems of trees or around the supporting structures of racks to prevent ants from climbing up and tending parasitizing scales in trees or from carrying away freshly sown seeds from racks.

Here again, these options require little effort to implement and usually blend in well with routine nursery operations. Such options should be sought wherever possible.

3. Biological Control

Three types of biological control shall be considered: Classical Biological Control, natural enemies, and use of biorational and biological pesticides.

I do not believe classical biological control to be a viable option in the nursery context. First, each nursery operates on a scale way too small and lacks host continuity through time to permit successful and permanent establishment of imported natural enemies. Second, classical biological control is a costly and institutionally burdening proposition. It usually involves years of research efforts, the building of rearing facilities, and the establishment of strict quarantine regulations and facilities to avoid the introduction of hyperparasites or perhaps worse, of other pests. A developing country such as Haïti lacks the funding, the institutional base, and the expertise to make such a proposition even salable. Third, biological control is still more an art than a science: There is no guarantee of success. In summary, classical biological control should be resorted to only in cases of national interest and when everything else has failed. The psyllid problem on Leucaena could end up in this category.

Natural enemies are a viable option as they diligently work behind the scene at no cost to the nurseryman or peasant, on the condition of their being present. In all my visits to nurseries I have not seen or caught natural enemies except for one spider, a cluster of Lacewing eggs, and a few parasitized aphids. Several reasons might explain this paucity of natural enemies. One explanation is that it always takes some time for natural enemies to find patches containing their hosts. Therefore we may conclude that they had not reached the nurseries yet at the time of the survey although a plentiful supply of host insect pests may have already been present within the nursery. Another explanation is that indiscriminate use of pesticides might just preclude their establishment. Yet another explanation is that there might be no or so few natural enemies around as to defeat the case. Therefore I cannot say for now whether nurserymen can rely on this form of biological control until further observations are made and its contribution rigourously assessed.

The last type of biological control involves the use of biorational and biological pesticides. These include Neem extracts, soaps, and biological insecticides such as *Bacillus thuringiensis* (commonly referred to as B.T. and sold under the trade marks of Dipel and Thuricide). Neem is definitely an attractive option as it constitutes a local resource that can easily be processed at the nursery level, providing the processing techniques are worked out and standardized. Soaps have to be imported but they rank high as they are non-toxic to humans and natural enemies. I advocate B.T. could be used to provide satisfactory control of caterpillars without having to deal with the pesticide safety issue.

In my opinion, more attention deserves to be devoted to this within the planned future Agroforestry Outreach Project research activities.

4. Plant Breeding for Resistance

Plant breeding for resistance is an option that may be costly in the short run but that pays for itself in the long run. Care must be taken however to seek resistance that will be durable, even though it may not provide 100% control.

I believe that the AOP's supporting organizations will have to embark on an importation and trial program of Leucaena tree species and varieties for resistance to psyllids in the hope to avert or, at least, minimize the potential disastrous effects of an infestation outbreak on the susceptible stock that has been so far outplanted country-wide.

On a lighter note, I would like to encourage seed collectors to collect seeds from trees growing in the same regions where seedlings grown from them will be outplanted, and exhibiting good development and growth characteristics and acceptable resistance to regionally occuring insect pests and diseases, either soil- or air-borne, in the hope of genetically passing on ecoclimatic adaptations and resistance to pests.

5. Seed Quality Control

This is a topic that I believe has already been addressed to some extent by the concerned organisations. Seed quality control can play a major role in the fight against diseases. High and uniform germination rates and success, disease-free seeds, proper storage methods and long shelf-life are all features of a good seed certification program that should contribute to significantly reducing seedling unthriftiness and death losses.

6. Chemical Control and Pesticide Application and Safety Concerns

Although I have not been able to observe first-hand how pesticides are applied and used in the agroforestry nursery context, I can only confirm concerns previously reported by other consultants; and add that it is highly likely that pesticides are generally used in an abusive fashion.

Previous concerns included improper repackaging, storage, and disposal of pesticides; improper maintenance and calibration of spraying equipment; improper protection of persons spraying pesticides; and improper choice of pesticide to use. These should continue to be the object of concerted efforts at improvement or rectification.

In addition, it appears that pesticides are very often used in a preventive fashion, say to protect seedlings from alleged grasshopper or cricket attack, even though the insect pest or its damage has not yet been seen. Also, a pesticide may be applied at first sight of feeding damage or of a caterpillar, even though that insect pest species may be opportunistic or may not be causing significant damage. Conversly and ironically, tens of racks may contain seedlings that are dying away from a disease that is both preventable and curable by a fungicide at hand but where no spraying is done.

Another form of pesticide abuse is the wide variation in pesticide dosages used. This survey indicates that dosages used will vary from one to three tablespoons per gallon for the same pesticide applied on the same tree species to combat the same pests.

B. SOCIO-ECONOMIC CONSIDERATIONS AT THE NURSERY LEVEL

Not only technical aspects but attitudes towards pest management problems need also be considered. I have observed much passivity and resignation on the part of nurserymen in the advent of high and sometimes disastrous losses (i.e. total writeoffs) due to pests. This attitude might be due to any number of the following, as inferred from my conversations with nurserymen:

(1) Nurseryman does not care. He is being paid to run the nursery and not on a per tree and/or quality output basis.

(2) Damage or loss is not perceived as being high, or economically important.

(3) Nurseryman believes seedlings may recover later on in the season, or once outplanted in the field.

(4) Nurseryman bypasses or disregards problem altogether by transplanting or growing more seedlings of whatever species appears to be doing well in the nursery in replacement of the species that do badly.

(5) Nurseryman feels helpless and powerless in front of what is happening and simply shows resignation.

(6) Nurseryman does not know where to look, or where to go, or whom to ask for help.

(7) Nurseryman is aware of the problem but will intentionally hide the fact from his supervising organization because he believes his aptitudes as a nurseryman are at fault, e.g. he believes the loss is due to his under- or overwatering or other fault, and fears this might put his job at stake should the project's supervisor know.

(8) Disease and insect pest control was not part of the nurseryman's original nursery production training and pest problems are, therefore, perceived as "should not be occuring" or "should not be of crucial importance in the running of the nursery". It may follow that the nurseryman feels that pest problems are not his concern, that he has done everything his job description and training required him to do and it is therefore not his problem if things do not work out.

Some of these points have already been mentioned by Cusson (1986) in his report. He commented that the AOP's pest management related problems were mostly due to a "lack of knowledge of what the pest problems are and how serious these problems really are".

Cusson also pointed out the fact that W. Suegrue's IEE of the Agroforestry Outreach Project dismissed the need for pesticides right from its onset and that the Nursery Production Manual only briefly mentioned potential pest problems in very general sorts of statements (Damping Off, caterpillars, aphids, etc.) and mostly recommended pesticides, although none in particular ("an insecticide may have to be used" is a typical recommendation, p. 9 of the Manual) with alternative methods of control being rarely recommended.

It follows that nurserymen lack the conceptual basis of what to look for, when to initiate control, decide on the extent of the harmfulness of the pest once detected and identified, and what range of control methods are available. The easy recommendation has always been to apply a pesticide as it covers up for ignorance of pest management facts and for less than optimum nursery management as is the case with over-watering, for example, which promotes damping off and root rot deseases. As such, the cause of the problem is not treated but only its symptoms: A nurseryman doesn't learn how to improve on his watering abilities – which could, by itself, solve a pest problem – but will instead lock himself into an addictive and abusive usage of pesticides.

The nurseryman's interlocking complex of attitudes towards nursery management may already appear too difficult to understand to allow one to come up with useful recommendations regarding means – technical or motivational – to step up production efficiency and quality. However, one clear point emerges: There's probably been and continues to be a lack of training and education in *both* the production and pest control aspects of nursery management. For instance, watering, plantspacing and shade management, three nursery practices which might be considered the core of nursery management, are still, to a greater or lesser extent, not properly carried out in most AOP nurseries. Pest control appears to have been paid little heed, so it is understandable that very little training has so far been procured in that field. I believe many of the attitudes mentioned above ensue from this lack of training. Feelings of helplessness and of not being in control of his own nursery operation because it is the white man who knows better, who sets the standards and is the problem solver; these are feelings which may result from lack of training and lack of continued upgrading of skills and technology through extension and seminars. In other words, nurserymen lack the resourcefullness and confidence – usually brought about by thorough training and support – to face problems and ask for help when in trouble.

Some feel that nursery personnel have had as much training as they can take and that the maximum level of efficiency has been reached, as concerns nursery production. It may be said that the nurserymen's low education and skills are to be blamed for this. I neither believe that nurserymen have had as much training as is possible, nor that low education and skills play an important role in this respect; most nurserymen I have met were quite astute and eager to learn and really intent on doing things right. Others may feel economic sanctions are what is needed to force nurserymen into producing higher quality seedlings. I do not believe this to be a valid argument either, because CARE's nurserymen, who are paid a flat monthly salary, produce higher quality seedlings and experience fewer pest problems, on the average, than PADF's nurserymen who are paid on a production basis. I believe that part of the discrepancy between PADF and CARE resides in the quality of the supervision and technical assistance brought to CARE's nursery personnel.

The fact that PADF's nurserymen are paid on a production basis may also be an incentive to try to grow as many seedlings as possible within the available rack space and with as little care as possible, so as to increase or at least maintain their income at an acceptable level. Of course this can lead to overcrowding of seedlings, untidiness of nursery site (weediness, racks laid on the ground, etc.) careless watering, use of cheaper materials such as local soil for potting, and disregard for production specifications such as inoculation and hardening off through shade removal and tree topping; as long as seedlings look reasonably healthy without. I recognize that entrepreneurship should be encouraged, but perhaps some other form of incentive should be sought to motivate nurserymen.

C. SOCIO-POLITICO-ECONOMIC CONSIDERATIONS AT THE PROJECT LEVEL

AID, PADF, and CARE all have a vested interest in the good running of the nurseries they sponsor and support. Their motives are several. First, there is the altruistic and legitimate desire of seeing that their monies are spent efficiently with maximum return on investment. Second, that the project benefits the poor by augmenting their incomes and improving their life conditions. Third, that an entrepreneurial spirit be instilled and institutionalized by fostering nursery growing as a viable employment and income generating industry in Haïti. And lastly, that the ecological trend of degradation be stopped, and hopefully, be reversed by achieving large scale and self-sustaining reforestation.

It follows, of course, that such motives entail responsibilities. One cannot expect such vast aims to be realized without full and constant motivational and technical support from the sponsoring organizations. AID, PADF, and CARE's images could be seriously damaged should the project fail to fulfill one or several of its objectives. Pest management is one area which could lead things astray if not paid proper attention.

First of all, there is the threat posed by possible psyllid infestations on present and future reforested areas which could, in the end, defeat years of reforestation efforts. The Haïtian people, likely, would ultimately blame the supporting organizations for letting the plague in and for abusing their trust since it was they who introduced tree growing in Haïti in the first place. All the organizations concerned should forestall this potential problem and to not simply disregard it and hope for the best.

During my various conversations with persons related to the project, there was some talk of adopting a purge policy which would induce nurseries which cannot be brought to comply with standards of efficiency and quality into phasing out. I believe AID/PADF/CARE have a moral obligation towards existent nursery personnel, as nursery growing constitutes for them a means of livelihood and hopes of entrepreneurial expansion. It could also be damaging to attempt to phase out nurseries as angry personnel could lead slander campaigns not only against the sponsoring organizations themselves, but also against reforestation efforts. I believe the intensification of technical and motivational assistance to currently unperforming nurseries constitutes a better approach to the problems of low efficiency and quality nursery production.

D. THE SYSTEMS APPROACH

Simple straightforward easy-to-follow recipes to bring Haïti's agroforestry nurseries' pest problems in check might have been recommended had they not been so far ranging and so intimately tied to the whole nursery production and project administration systems.

A systems approach is called for in this particular situation,if a serious attempt at preventing pesticide abuse and pest damage is to be made. Technical improvements such as the use of quality seeds and resistant varieties should be accompanied by an intensification in training and education in both the production and protection aspects of nursery management. Calling upon single sledge-hammer tactics such as pesticide sprays could only set off disastrous events and increase the risks of pesticide misuse and poisoning. I believe that all aspects of nursery production promoting pest damage should be concurrently addressed in order to come up with a viable and harmonious production system. This of course will require even greater concerted efforts and commitments on the part of AID/PADF/CARE and their willingness to do so is indicated in the research team and in the program AID has been planning to set up for the duration of the current phase of the AOP. One can expect that by introducing new technology, however low, new problems will crop up which will require the introduction of new technology for reaching a solution. Having given birth to a project, one has to see it through to adulthood,by which time self-sustenance and self-management have been reached.

RECOMMENDATIONS

This survey has shown that complex interrelationships exist between the different components of the nursery production system and its pest problems. Many pest problems, especially plant diseases, have been found to be related to less than optimal nursery management. Other pest problems will crop up that will be highly injurious regardless of how badly or well managed a nursery is and will, therefore, necessitate special intervention. There is an obvious need for consciousness-raising and for more and continued training of AOP's nursery and supporting personnel as regards production and pest control aspects of nursery management. The following recommendations are statements of higher level research and training needs that should be addressed jointly with the specific lower-level pest management recommendations that have already been made.

Recommendation # 1: That research be conducted at the nursery level to determine how much and for how long shading should be afforded to seedlings with the objective of keeping it to a minimum to avoid damage by powdery mildews. This research could be carried out by nursery personnel under the supervision of team leaders and nursery specialists.

Recommendation # 2: That an importation and resistance trial program be established for the procurement of psyllid-resistant Leucaena varieties.

Recommendation # 3: That research aimed at establishing the life table of nurseries' crops be conducted in order to assess fully their insect pest damage range and for the purpose of determining the most injurious species and need for control. I estimate this would require hiring an entomologist full time for at least one season. Research would take place in a maximum of 2-3 representative nurseries with easy road access and located within a reasonable distance from one another.

Recommendation # 4: That a survey be conducted to determine the population dynamics of psyllids on field-planted Leucaena trees for the purpose of assessing how much population regulation is afforded by environmental factors such as climate and populations of natural enemies, if present. This should provide an assessment of the risks of psyllid outbreaks on the country's Leucaena outplantings and may indicate the resistance features and level which should be sought. An assessment of natural enemies populations could also indicate whether importation of predators and parasites should be considered and attempted. I estimate this research would require hiring an entomologist to tour the country for a period of about 2-4 weeks, preferably overlapping the dry and rainy seasons, and take observations on abundant samples of natural enemies.

Recommendation # 5: That a Seed Certification or Quality Control Program be established to supply nurserymen with seeds that have a high germination rate and success, that are disease-free, and which produce seedlings that are adapted to the eco-climatic and pest conditions encountered in the regions of their outplanting.

Recommendation # 6: That the Pesticide Application and Safety Practices Training Program be pursued and intensified to address areas of immediate concern such as pesticide repackaging, storage, and disposal, safety to pesticide applicators, and appropriate spraying techniques.

Recommendation # 7: That a Pest Recognition and Management Training Program be instituted to educate nurserymen, foresters, and project managers on the topics of damage and pest recognition, action thresholds and timing of application, control methods, and Integrated Pest Management. I estimate this would require hiring a pest manager for a period of a few weeks to tour the main regional centers and give a one or two day seminar to assembled nurserymen.

Recommendation # 8: That new and untrained nurserymen be sent on apprenticeship trainings in successful nurseries for one whole season before being allowed to manage a new nursery; or to return to their appointed nursery, so as to learn the secrets of the trade under the auspices of a dedicated and competent nurseryman.

Recommendation # 9: That continued technical assistance as regards pest management be provided in the form of an extension service by a resident pest manager or nursery specialist with pest management inclinations.

Recommendation # 10: That a paper be written out of this report for publication so as to make this pest survey's information, which I consider valuable and original, i.e. as not having been previouly published, accessible to other groups working on similar agroforestry reforestation projects around the world.

APPENDIX I.

PEST INFO SHEETS

DAMPING OFF DISEASES

Scientific name: Pythium spp.
Class: Phycomycetes
Geographical distribution: Widely distributed.
Hosts: All nursery-grown species are susceptible and particularly *Casuarina equisetifolia, Leucaena leucocephala*, and *Swietenia macrophylla*.

Symptoms: The disease affects seeds, seedlings and older plants. Damage can be done to the seed and seedling roots during germination either before or after emergence. These two phases of the disease have been termed pre- and post-emergence damping off, respectively.

Infected seeds fail to germinate, turn into a soft creamy-colored mushy mass, then turn brown, shrink, and finally desintegrate. Infection by the damping-off fungus can also take place after the seed has germinated but before the seedling has emerged above the soil line. Infection in the soil cannot be directly noticed and the only manifestations of the disease are poor stands. Poor stands are often mistakenly believed to be due to poor seed germination whereas the actual cause is damping off (fig. 7).

Seedlings that have already emerged are attacked at the roots and sometimes at or below the soil line. The invaded tissues become water-soaked and discolored, and the cells soon collapse, causing the basal part of the stem to become soft and thin. As a result, the seedling falls over and finally withers and dies as the fungus continues to invade it.

Older plants are seldom killed when infected with the damping-off fungus but can develop root or stem lesions, their growth may be retarded considerably, and their yields may be reduced drastically.

Epidemiology: The fungus produces zoospores which can swarm about in water until they come to rest, encyst, and germinate by producing a germ tube. The germ tube may then infect the host. *Pythium* spp. are widely distributed in waters and soils throughout the world.

Severity of disease and amount of losses are greater when (1) the soil remains water-soaked for prolonged periods of time, (2) when there is an excess of nitrogen in the soil, (3) when unsterilized soil is used or when crop is planted in the same unsterilized containers for several consecutive seasons, (4) when seeds are planted too deep or germinate too slowly, and (5) when seedbeds are sown too thick, thus favouring a rapid spread of the disease.

Control: Damping off can be effectively controlled in the nursery setting through proper cultural practices. Good soil drainage, careful watering, good air circulation among plants, careful fertilization, appropriate seed depth, use of sterile growing media only, culling of diseased and withered seedlings, use of fast-germinating seeds, use of clean water, and appropriate seeding rate or plant spacing are all cultural and sanitation practices that can help prevent infection and spread. Host resistance is not generally high but can be sufficient to be of economic importance.

In addition, it is advised to chemically treat the seed with a dressing of thiram, captan, or any other suitable fungicide. Should the disease appear and cause appreciable losses, spray with captan at once and repeat at 4-5 day intervals. Captan added to the first watering often improves stands.

POWDERY MILDEWS

Scientific name: Oidium spp. (imperfect stage)

Class: Ascomycetes and imperfects.

Geographical distribution: Encountered throughout the Central Plateau and the North-West Peninsula but likely to pose a problem in all regions of Haïti.

Hosts: Species that are most severely affected are papaya (*Carica papaya*) (fig. 17 & 18) and *Casuarina equisetifolia.* High disease incidence was also recorded in *Cassia siamea* (fig. 19 & 20) and *Acacia auriculiformis* but no losses of seedlings could yet be observed at time of appraisal. Three *Oidium* spp. causing powdery mildew of papaya have been described (Holliday, 1980). These are *O. caricae, O. caricae-papaye*, and *O. indicum.* According to Dr. Jean Vernet Henry, plant pathologist at Damien, all three species occur in Haïti. I could not find records of specific powdery mildew species attacking Casuarina, Cassia, and Acacia in the literature. I contend, however, that knowing the type of disease and genus is amply sufficient for purposes of identification and control.

Symptoms: Powdery mildews are probably the most common, conspicuous, widespread, and easily recognizable plant diseases. They are characterized by the appearance of white to greyish, powdery, mildewy growth on young plant tissues (fig. 16). As the seedlings grow and new leaves emerge, the disease becomes most noticeable on the oldest leaves, giving the false impression that the fungus actually attacks oldest leaves first. Tiny, pinhead-sized, black spore-bearing structures may be present singly or in groups. The fungus is most commonly observed on the upper sides of the leaves but it also affects the undersides of leaves, and the young shoots and stems.

Epidemiology: Powdery mildew is mostly a disease of warm, dry climates. Only conditions of high relative humidity (without need for the presence of free water on the plant surfaces) are required to cause spore release, germination, and infection. Once infection has begun, the mycelium continues to spread on the plant surface regardless of the moisture conditions in the atmosphere. Thus, the disease develops best during the driest but coolest period of the year. But epidemics of the disease, during an otherwise dry season, are closely associated with infrequent showers of short duration, with high humidity and excess of dew in the nights and early mornings. Conversely, heavy rains of long duration, which maintain leaf surfaces wet for prolonged periods, and bright, sunny, hot weather are unfavourable to the fungus. Powdery mildews are essentially diseases of young leaves, mature leaves acquiring immunity because of cuticle hardening.

Control: I contend that the nursery setting as found in Haïti is largely responsible for the ravages caused by powdery mildew diseases. Nurseries operate during the dry seasons of the year and customarily provide shade to the seedlings for the first 5 to 6 weeks of the growing period, and sometimes for an even more protracted time span. Watering is usually carried out every morning and sometimes, again in the evening. Thus, all conditions favourable to disease development, that is a dry and cool environment, frequent showers of short duration, and high relative humidity if overwatering and overcrowding are prevalent, are met to set the scene for a disease outbreak. Control in this case will mainly consist of proper cultural practices. Give shade only as much and as long as required; undue extension will augment risks of disease outbreak all the more. Water in the morning and only as required. Provide ample space among seedlings to allow good air circulation.

If the disease appears and shade cannot be removed, spray sulphur, dinocap or benomyl (Benlate) at weekly intervals. More frequent applications may be required during development of new growth, temperature fluctuations, and frequent waterings or rain.

CERCOSPORA DISEASES

Scientific name: Cercospora spp.
Class: Ascomycetes and imperfects.
Geographical distribution: Have been mostly observed throughout the South Peninsula where a more humid disease-favouring environment is prevalent, but can also become a problem in the North. Less likely to become a problem in the drier Central Plateau area.

Hosts: Cassia siamea is the single most susceptible nursery species and can become severely infected when conditions for disease development are favourable. Browne (1968) reports a record of Cassia leaf spot in Africa caused by *C. cassiae.*

Neem (*Azadirachta indica*), Acacia (*A. auriculiformis*) and coffee (*Coffea arabica* var. *typica*) can also become infected, although generally not as severely as Cassia. *C. leucostica* and *C. subsessilis* or *meliae* have been reported (Browne, 1968) as causing leaf spots on Neem. *C. coffeicola* causes Brown Eye Spot of coffee.

I have not found records of Cercospora diseases on Acacia in the literature.

Symptoms: They are almost always leaf spots that either stay relatively small and seperate, as for Cassia(fig. 21 to 26), or they may enlarge and coalesce resulting in leaf blights, as for severe infestations in Neem.(fig. 28 to 31)

The leaf spots in Cassia are brown to chesnut-coloured, sometimes almost black, small, about 3 to 5 mm in diameter and irregularly circular to angular in shape with somewhat black borders(fig. 21 & 22). Later their centers become ashen-gray, thin, papery and brittle and may drop out leaving a ragged hole appearance; or the spots, if sufficiently numerous, may merge producing large necrotic areas. On Neem and Acacia, the leaf spots are small and yellowish at first, but they rapidly enlarge, with the affected tissue becoming water-soaked or changing to a light brown colour and a dry, papery texture(fig. 32 & 33). The spots, which are irregularly shaped and with or without a distinct border, coalesce to form large blighted areas(fig. 30). In severe attacks, similar lesions may develop on the stem and petioles and girdle the seedling(fig. 31). Eventually, all the foliage is destroyed, droops, dries up, and may fall off. Small black blobs, which are fruiting structures called pycnidia, producing conidia spores, may sometimes be seen on the upper surface of the dry papery-textured lesions and they usually appear in concentrically developed patches in the center of the lesion.

Symtoms on Acacia resemble those on Neem except that lesions are mostly large and narrow, extending lengthwise, parallel to the main veins of the blade like leaves. Eventually the foliage dries up and seedlings appear blighted.

The Brown Eye Spot disease of coffee can infect both leaves and berries. On leaves, the disease initially appears as small chlorotic spots which later expand to produce a thin, brownish to greyish, central area, usually bearing dark tufts of spore-bearing structures, bordered by a brown necrotic zone with an outermost chlorotic or yellowish halo(fig. 34). Lesions are circular to oval, 5-15 mm in diameter. The disease causes shedding of foliage when severe and infected berries are difficult to process because the pulp sticks to the beans.

Epidemiology: The fungus produces spores that are easily detached and often blown long distances by the wind. The disease is favoured by high temperatures and therefore is more destructive in warmer climates. Although Cercospora spores need water to germinate and penetrate, heavy dews seem to be sufficient for abundant infection. The fungus survives in or on the seed and as minute black stromata in old affected leaves.

Control: Cultural practices are the primary line of defense against Cercospora diseases. Use disease-free seed. Using seed at least three years old by which time the fungus in the seed has died is also recommended at times as long as seed viability remains at an acceptable level. Provide good air circulation by spacing seedlings out. Water seedlings in the morning. Good air circulation, sun and rising temperatures allow fast drying of leaves and thereby prevent spore germination and infection.

C. coffeicola can be more severe under nursery conditions because seedlings and plants are often overcrowded. There are reports that the practice of shade removal in coffee cultivation has apparently made the disease more prominent; shaded plants tend to have less disease. Incidence of the disease on unshaded plants can be reduced by applying increasing amounts of NPK. Provide shade trees or a shade cover.

Finally, chemical control is recommended when everything else has failed. Spray seedlings with fungicides such as benomyl, Bordeaux mixture, maneb, or any other suitable fungicide.

VIRUS DISEASES

Scientific name: Unidentified.

Class: Unidentified.

Geographical distribution: Observed in only one instance in the Central Plateau area.

Hosts: The affected species were Ced (*Cedrela odorata*) (fig. 38), Chen (*Catalpa longissima*) (fig. 39) and Bois capab (*Columbrina arborescens*) (fig. 37). Bois capab was the single most susceptible species.

Symptoms: The most conspicuous symptom is that of reduced growth rate, resulting in various degrees of dwarfing or stunting of the entire seedling. The virus is present throughout the plant (systemic infection). Mosaic-type symptoms, characterized by light-green, yellow, or white areas intermingled with the normal green of the leaves, and which can be described as mottling, were also observed. Bunchy tops, veinclearing, misshapen leaves, and veinreddening are some of the other symptoms that can be observed on Bois capab (fig. 37).

Epidemiology: I suspect the Citrus aphid (*Toxoptera* spp.) is responsible for the transmission of the virus.

Control: Use virus-free seed. Control the insect vector and remove weeds which may serve as alternate hosts. Rogue and burn infected seedlings as soon as symptoms appear.

PSYLLIDS

Scientific name: Heteropsylla cubana
Family: Homoptera:Psyllidae
Geographical distribution: Seen throughout the country. Populations were particularly high in the South-West Peninsula's nurseries.

Hosts: Leucaena leucocephala and saman (*Samanea saman*).

Damage: Primary damage is done by nymphs to the young shoot which become coated with sooty molds growing off the honeydew exudates of the insect (fig. 42). The presence of sooty molds in Leucaena is the surest sign of a psyllid infestation. Under severe infestations, leaflets may curl and fall off and the young shoot may die back. Although I have not seen complete defoliation in Haïti's agroforestry nurseries, it has been reported to occur in the Philippines in mature Leucaena plantations.

Life history: Very little is known yet about this newly devastating pest of Leucaena. Psyllids were recorded in Florida and the Dominican Republic in 1983, in Hawaii in 1984, and in the Pacific Islands (Western Samoa, Philippines, etc.) in 1985 (Fernandez, 1986), where they quickly became a key pest of Leucaena. Movement of the psyllids around the world has been hypothesized to take place through (1) high-altitude air movements, e.g. typhoon and monsoon winds; (2) international trade as cargo in airplanes; and (3) transmission on air- and sea-shipped live plants.

Eggs are laid on young foliage and hatch in 2-3 days. A single female psyllid can lay up to 400 eggs. Five nymphal instars then develop which cover 8-9 days. Adults live 6-10 days (Fernandez, 1986).

Control: Three main areas are being investigated: natural enemies, resistance, and chemical control. Outstanding predators in Hawaii are the ladybird beetles *Curinus coerulus* (Mulsant), introduced in 1922 from Mexico to control the coconut mealybug, and *Olla abdominalis* (Say). Natural enemies are believed to be effective in the Caribbean since Leucaena psyllids are known throughout the Caribbean and the east coast of Mexico, where they appear to be highly predated upon and rarely cause severe damage (NFT Highlights, Feb. 1986). However, the literature does not mention any specific record of psyllid control by natural enemies in Haïti and my personal observations indicate that it is inexistent or very low, at least in the nursery setting context. Importation of natural enemies might have to be considered should existing natural enemies and other control methods such as resistance fail to keep damage under tolerable levels.

Resistance has been observed in many species of Leucaena, notably *L. esculenta*, *L. colinsii*, and *L. retusa*. *L. leucocephala* varieties K527, K538, K584, K591, K636, K656, and K658 have shown high resistance in Hawaii (NFT Highlights, Feb. 1986). Fernandez (1986) provides an account of the resistance screening results that have been obtained in Hawaii by Dr. J. Brewbaker. Use varieties that have been shown to be resistant to psyllid attack in Haïti whenever possible.

Tests in the Philippines have shown that spraying with Azodrin 202R, Sevin 85S, Lannate, Neem oil, or soap give good control. The insecticide rates were 0.075 c/o a.i., Neem oil was 120 ppm, and the soap solution was 10% (Beigonia *et al.*, 1986). Use soaps or Neem extracts whenever possible so as to avoid pesticide toxicity to both humans and natural enemies.

CITRUS APHID

Scientific name: Toxoptera aurantii (B. de F.)

Family: Homoptera:Aphididae

Geographical distribution: South-West Peninsula and Plateau Central. Likely to be widespread throughout the country.

Hosts: Citrus and Bois capab (*Columbrina arborescens*) mostly. But also Ced (*Cedrela odorata*) and Chen (*Catalpa longissima*). May also be found on tea, cocoa, and coffee bushes and other plants (Hill, 1975).

Damage: Shrivelling up of young leaves is the most conspicuous symptom together with the appearance of black sooty molds on the upper surfaces of leaves. If unfolded, infected leaves show clusters of brown and black aphids. Only flush growth is attacked. Symptoms of virus diseases may appear as the Citrus aphid can vector plant viruses.

Life history: The adults are shiny black and may be winged or wingless. Only females are present, and they produce live young which are brown in colour. A generation probably takes only 7 days to complete under favourable weather conditions.

Control: Control measures should only be applied in periods of flush growth, when the recommended insecticide is dimethoate as a full-cover spray in water, and care should be taken to thoroughly wet the flush leaves. Dimethoate should not be used on rough lemon trees or on non-budded rough lemon stock.

COTTONY CUSHION SCALE

Scientific name: Icerya purchasi Mask.

Family: Homoptera:Margarodidae

Geographical distribution: North-East Peninsula but likely to be widespread throughout the country.

Hosts: Citrus spp. mainly, but can also attack many other plants, especially mango.

Damage: The leaves and twigs are infested with large, white, fluted scales, and infested leaves often turn yellow and fall prematuraly. Heavily infested young shoots are killed, and in fact whole nursery trees can be killed. Copious quantities of honeydew are excreted and black sooty molds appear on the upper surface of the leaves.

Life history: The adult female is markedly distinctive, being quite large (about 3.5 mm), sturdy, with a brown body covered with a layer of wax. The white, fluted egg-sac which is secreted by the female constitutes the most showy part of the insect. The egg-sac usually contains more than 100 red, oblong eggs. The hatching period is from a few days to 2 months, according to climate. The three nymphal stages are shiny, reddish insects, and they are most abundant along the midrib under the leaves. The adult scales are most frequently found on the twigs and shoots.

Control: The Cottony Cushion Scale constitutes an example of classical biological control. It was the first sustained effort in the importation of natural enemies from one country to another for control of an insect pest. The whole citrus industry in California was threatened with destruction by the scale by the mid 1880's. Importation of *Rodalia cardinalis*, better known as the vedalia beetle, from Australia achieved complete control of the scale within a little bit more than a year of release. This scale is therefore usually controlled naturally by the vedalia beetle which has been introduced from Australia into most Citrus growing areas of the world. I do not know whether the vedalia beetle has ever been introduced in Haïti.

However, within the agroforestry nursery context, biological control may prove insufficient or may not be easily manageable (e.g. chemical sprays for the control of other pest insects can readily upset natural control of the scale, if present). I have not seen natural enemies in the field and a more extensive survey would probably be warranted to determine whether there are any present and evaluate their potential impact on the Cottony Cushion Scale populations.

To allow predators to work effectively, it is also important to control the ants that tend and protect the scales against predators so as to collect the honeydew secreted by the scales.This is easily achieved by wrapping a sticky band around the base of the plant's stem, thus preventing the ants from climbing up the plant and reaching their "herds".

If chemical control of the scale populations is required, then azinphos-methyl or malathion should prove effective

CORN SEED MAGGOT (BEAN SEED FLY)

Scientific name: Hylemya platura (Meig.) (Identification should be confirmed during a subsequent assignment by rearing the adult from the maggot.)

Family: Diptera:Anthomyiidae

Geographical distribution: Encountered in the North-West Peninsula only, where it overlapped with its host's geographical distribution for the spring dry season of 1987. Could well occur in the other regions of Haïti, should its host be grown there, too.

Hosts: Saman (*Samanea saman*).

Damage: Maggots attack sown seeds and bore into the cotyledons of saman, often while the seedling is emerging. Severely infested cotyledons fail to split open to give way to the young developing shoot and turn into a mass of frass. Seedling growth completely aborts then. Cotyledons soon shrivel and shrink, and the whole seedling withers away. The maggot can also attack emerged seedlings, where it bores into the soft skin and causes the seedling to fall over.

Life history: Female flies lay their eggs on freshly disturbed soil. Each female lays about 100 eggs, a few at a time, over a period of 3-4 weeks. Hatching takes 2-4 days, occasionally longer under cool conditions. Larvae are typical muscoid maggots with 3 instars (12-16 days total for development). Puparia are 5 mm long and dark brown. Pupation takes place in the soil, either in the Rootrainers or in the soil directly below the Rootrainer-supporting racks. The adults look like very small house flies and live 4-10 weeks. There might be 2-5 generations per year and the life cycle may be completed in 4-5 weeks under warm conditions.

Control: Dress seeds with ethion, diazinon, pirimiphos-ethyl, or trichloronate. However, care must be taken with diazinon for higher dose rates show marked phytotoxicity. Because of toxicity and hazard to operators use of trichloronate in some countries is not approved (Hill, 1975).

Because of the small scale of nursery operations, it could be economically feasible to physically prevent egg-laying in the Rootrainers by laying a fine-mesh mosquito-net over the Rootrainers to be removed upon seedling emergence, by which time the plant's susceptible stage is passed and the plant can escape attack. This method deserves testing and could prove successful, thus bypassing the need for toxic chemicals.

LIST OF FIGURE CAPTIONS

Fig. 1. Symptoms of acute under-watering in Chadec (*Citrus grandis*). Note rolled-up, drooping leaves, and withering of seedlings. Only top one inch of plug has adequate moisture.

Fig. 2. Symptoms of underwatering in *Citrus* spp.

Fig. 3. Symptoms of nutrient deficiencies in *Citrus* spp.

Fig. 4. Transplanting damage on Neem's roots. Note the looping (!) of the root around itself.

Fig. 5. Anthracnose lesions on mango leaves.

Fig. 6. Casuarina seedlings showing Rhizoctonia damage. Top left seedling is healthy. Note dry rot (blackening of stem) which progresses from base of seedling upwards. Seedling finally withers (bottom left seedling). Compare healthy vascular system of seedling to the left with that of the seedling to the right (diagonal cross-sections of stems).

Fig. 7. A rack of Mahogany seedlings showing about 80% loss to damping off.

Fig. 8. An example of an untidy nursery. Note racks laid on the ground in the middle alley and alien vegetation growing amidst.

Fig. 9. An example of a very tidy nursery. Note racks raised well above ground for promoting good air circulation and for facilitating care. Note also the absence of alien vegetation.

Fig. 10. Another example of a tidy nursery with racks raised above concrete flats for preventing growth of alien vegetation.

Fig. 11 and 12. Weeds growing amidst the nursery prevent good air circulation, may serve as reservoirs for insect pests and diseases, and may provide shelter to rodents.

Fig. 13. Scale infestation on *Citrus* spp. Note sooty molds growing on the upper sides of leaves and the scales on the lower sides.

Fig. 14. Close-up of a *Citrus* leaf coated with sooty mold.

Fig. 15. Close-up of a *Citrus* leaf infested with scales.

Fig. 16. Powdery mildew on Acacia. Note the greyish, powdery growth on the leaves.

Fig. 17. Powdery mildew on papaya. Note the foci of infestation and the chlorotic appearance of leaves.

Fig. 18. Dried papaya seedlings showing powdery mildew damage. Note various degrees of stunting and faint yellowish or creamish spots on the leaves. Plant in upper left corner is healthy.

Fig. 19. Dried Cassia seedlings showing powdery mildew damage after receding of the disease due to exposure to the sun. Note water drop splash pattern of necrotic lesions. Note also that lesions appear on older leaves, although these were attacked by the fungus when young.

Fig. 20. Same as 19 but note greyish powdery growth still remaining on one of the leaflets of the first leaf.

Fig. 21. Cercospora damage on young Cassia seedlings.

Fig. 22. Close-up of Cercospora damage on young Cassia seedlings. Note irregularly circular lesions with ashen-grey center and dark margin.

Fig. 23. Older Cassia seedlings showing severe defoliation due to Cercospora.

Fig. 24. Close-up view of Cercospora lesions on Cassia.

Fig. 25. Another close-up view of Cercospora lesions on Cassia.

Fig. 26. Cercospora damage on live Cassia seedlings. Note various degrees of stunting and severe defoliation.

Fig. 27. A rack of Cassia seedlings which was decimated by Cercospora and which was refilled with Leucaena transplants. Note the few chlorotic Cassia seedlings left against the green foliage background of Leucaena.

Fig. 28. Neem seedlings showing Cercospora damage. The seedling on the left is healthy. Note various degrees of stunted growth, the chlorotic leaves, and the stem lesions.

Fig. 29. Dried Neem seedlings showing Cercospora and transplanting root damage.

Fig. 30. Neem leaves showing Cercospora lesions. Note the fact that chlorosis extends to the whole leaf from the few lesions.

Fig. 31. Withered Neem seedling. Note Cercospora stem lesion.

Fig. 32. Cercospora damage on Acacia. Leaves become water-soaked and dry up. Lesions have indefinite borders. Seedling to the left is healthy.

Fig. 33. Cercospora damage on dried Acacia seedlings. Note elongated and narrow lesions. Also note healthy root system.

Fig. 34. *Cercospora coffeicola* lesions on coffee leaves.

Fig. 35. Wither-tip and die-back symptoms on *Citrus* spp. believed to be due to anthracnose.

Fig. 36. Close-up of wither-tip and die-back symptoms on *Citrus* spp. Note the brownish concentric lesions on the blighted areas.

Fig. 37. Virus damage on Bois capab. Note stunting, veinreddening, bunchy tops, and mishapen leaves.

Fig. 38. Virus damage on Ced. Plant in the middle is relatively healthy. Note severe stunting and chlorosis.

Fig. 39. Virus damage on Chen. Plant in the middle is healthy. Note severe stunting and chlorosis, with veins remaining green.

Fig. 40. Mite feeding damage on Ced. Note the speckled appearance of leaves.

Fig. 41. Nematode damage on Chadek. Note faint chlorosis and severe defoliation. Lesions are apparent on roots.

Fig. 42. Dried Leucaena plant showing psyllid damage. Note tip die-back and sooty molds on new shoot.

Fig. 43. Limb of a *Citrus* spp. tree severely infested with the Citrus Snow Scale.

Fig. 44. Close-up of 43. White scales are males and brown scales are females.

Fig. 45. A mature Casuarina tree growing in the midst of a nursery. Tree may provide a reservoir of infestation and a host continuum over seasons for insect pests and diseases of Casuarina seedlings grown right beneath it.

Fig. 46. A pest manager should expect encountering the weirdest situations. Look at this coconut seedling before...

Fig. 47. ... and after a free-roaming cow has come by! Shall we classify her as a vertebrate pest?

APPENDIX II.

CURSORY EXAMINATION OF POSTHARVEST INSECT PEST DAMAGE TO LOGS OF OUTPLANTED NURSERY TREE SPECIES

A. INTRODUCTION

I was asked by Mr. Jerry Grosenick, economist with the U. of Maine, to examine post-harvest insect pest damage to logs of outplanted nursery tree species. The survey took place at his home in Port-au-Prince on the 16th of March. Some of the tree species I examined were the Neem tree (*Azadirachta indica*), *Leucaena leucocephala*, and *Cassia siamea*. The results of this survey are described in the following section. Since the survey was outside my original scope of work, only cursory examination and identification were attempted. Insect pests were keyed down to at least the family, and down to the genus, whenever this could be done easily – without the use of complex identification keys – due to the pest's wide-spread economic importance or based on key morphological characteristics of the genus.

B. INSECT PEST SURVEY

Only Cassia and Leucaena appeared susceptible to post-harvest insect damage; Neem showed little or no damage. The insect pests surveyed comprise the metallic wood-boring beetles, the powderpost beetles, bark beetles and termites. These shall be discussed in turn.

Metallic Wood-Boring Beetles

Metallic wood-boring beetles belong to the family Buprestidae. Although no live beetles were found, their characteristic damage could be readily identified.

The larvae bore under the bark and occasionally into the wood. The galleries under the bark are characteristically winding and filled with frass; the galleries in the wood are oval in cross section and usually enter the wood at an angle.

Damage was extensive and mostly on Cassia.

Powderpost Beetles

Logs, most particularly those of Leucaena, were highly infested with powderpost beetles (Coleoptera:Lyctidae). These beetles derive their name from the characteristic damage they do: they bore into dry and seasoned wood and reduce it to a powder, which can be seen flowing out of the beetles' exit holes when an infested log is tapped gently against a hard surface.

The beetles live in the wood for months, and timbers from which the adults have emerged are peppered with tiny holes, as though fine shot had been fired into them.

The powderpost beetles are slender and elongate, uniformly coloured brown to black. The species found was 3-4 mm in length.

Bark Beetles

Tiny, one mm long, black bark beetles (Coleoptera:Scolitydae) were found underneath the bark, aggregated in patches of several tens of individuals. No extensive damage was apparent and infestation seemed low.

Termites

Damage by termites was fairly extensive. The species found was identified as belonging to the family Termitidae, and most probably to the genus *Nasutitermes*, the soldier caste being nasutiform. The individuals of this caste, unlike soldier castes of other species which characteristically have greatly enlarged heads and mandibles, possess a snoutlike, pear-shaped, head through which a sticky secretion can be exuded or squirted at an intruder. Characteristic covered passageways made of mixed earth and faecal material were also seen running along logs. These protect the termites from enemies and desiccation as they move feverishly between nest and food source.

Larvae of rove beetles (Coleoptera:Staphilinidae) were also collected which indicates that some predation was going on, most probably on termites, as many rove beetle species occur in nests of ants and termites, but possibly on the other wood-boring insects as well.

APPENDIX III.

INSECT PEST AND DISEASE SURVEY OF PEASANT'S AGRICULTURAL CROPS IN THE MAISSADE WATERSHED MANAGEMENT PROJECT AND EVALUATION OF FURTHER ASSESSMENT AND RESEARCH NEEDS

A. INTRODUCTION

On March 19, at the request of Mr. Dean Treadwell, I conducted a cursory pest insect and disease survey of peasant's agricultural crops in support of the Maissade Watershed Management Project. Maissade is located in the Central Plateau of Haïti, west of the city of Hinche. The survey took place in a small village called Mme Joa, located some 30 km west of Maissade.

Due to the time of the year, there were very few crops in the ground to survey. In most cases, stored samples were brought to me which were infested with insect pests. I also had to rely partly on the peasants' description of their pest problems for identification.

As I understand, the main thrust behind this survey is to design a cropping system for peasants that will allow them to plant a cover crop during the dry seasons of the year so as to conserve soil; thus replacing the time-old practice of burning the corn or sorghum stubble, which is destructive of the soil structure and further promotes water erosion. However, peasants fear new and worse pest problems may be brought by the proposed new cropping system and they are unwilling to switch over unless those problems are first addressed and resolved. There appears to be pest problems associated with both not burning the stubble and growing a cover crop. The cultural practice of burning the stubble may carry a lot of wisdom as it probably constitutes a means of reducing corn-infesting insect populations such as borer species. Also, not burning the stubble and growing a cover crop might, in addition to increasing corn insect pest problems during the growing season, lead to increased rat problems year round.

Obviously, this is a very complex situation which cannot be evaluated at a glance but which requires in-depth assessment and research. I could not, for instance, identify corn insect pests and diseases and evaluate losses because there was no corn crop in the ground. Examination of corn stubbles though revealed extensive tunneling by borers. How extensive the rat problem is or could be, should a cover crop be sown, could not be evaluated either, for obvious reasons. The pest issue is no doubt crucial to the successful implementation and adoption of the new cropping system and deserves full attention and the expenditure of further assessment and research efforts so as to come up with a well thought-out and ecologically stable system.

The following chapter nonetheless provides an account of the pest insects and diseases that were identified on some others of the peasants' food crops. These seemed to call for immediate and full attention as well as they appear to take a large toll of what already constitutes a meagre harvest.

B. INSECT PEST AND DISEASE SURVEY

The insect pests and diseases identified were the sweet potato weevil, the banana weevil, tuber rot of yams, smut and red rot diseases of sugarcane, and anthracnose of cashew. The symptoms or damage and the control methods for these shall be briefly described in turn.

Sweet Potato Weevil

The sweet potato weevil (*Cylas formicarius*) is a serious pest of sweet potatoes (*Ipomoea batatas*). The larvae bore throughout the tubers leaving dark-stained tunnels. Damage continues during storage which makes this pest even more of a concern.

Eggs can be directly deposited in tubers and develop into white and curved larvae which bore inside both stems and tubers; the tunnels are about 3 mm in diameter. Pupation can take place inside the tubers, but more often in the soil. The adults are small black weevils about 6-8 mm long; they have wings and can fly quite well. They usually appear in the fields at the time of tuber formation. The whole life cycle takes some 6-7 weeks; there are several generations each year.

Control can be achieved through several means. Continuous cropping of sweet potatoes keeps weevil populations high. Thus, crop rotation is one method of reducing losses. Very dry soils also assist the movements of adult weevils and increase their infestation levels. In this connection, it has also been observed that drought resistant, leafy sweet potato varieties tend to maintain more moisture in the ground and reduce the activity of adult weevils.

Krantz *et al.* (1977) report that varietal resistance has been recorded at the International Institute of Tropical Agriculture, Ibadan, Nigeria. More on this topic should be available in the recent literature.

Destruction of infested plant material after harvest by burning also reduces the level of infestation. Planting of healthy vines and an early harvest can also reduce damage. Foliar sprays by themselves are of little value but it has been shown that the dipping of planting slips in a DDT solution gives good control (Hill, 1975). Because of possible residue problems in the tubers, no persistent insecticides should be applied to the soil.

The Banana Weevil

The banana weevil (*Cosmopolites sordidus*) is considered to be the most serious insect pest of bananas. Infestations are typically spread through the movement of infested suckers used as planting material.

The larva bores irregular tunnels in the rhizome and pseudostem at ground level. The tissues surrounding the tunnels turn brown and rot. If the stem is small, the banana variety susceptible or the infestation very heavy the plant will show symptoms of wilting and then die. Older plants may survive the attack but show reduced growth and are easily blown over during stormy weather. Secondary fungal and bacterial infections accelerate the process of plant decline.

Adult borers feed on dead or dying debris and are nocturnal in habit, living under cut pseudostems where the humidity is high. The female lays her eggs singly in small pits made in the pseudostem at ground level. The larva is a white, legless grub with a brown head capsule. It extensively tunnels into the corm for several weeks and then pupates within the plant. Newly emerged adults are brown but turn almost black within a few days. The adult does not usually fly; migratory movement occurs at night by crawling.

Control mainly consists of appropriate cultural methods that, if employed, should keep weevil populations below that level which causes significant damage, thus obviating the need for specific control practices. These include: the use of weevil-free suckers (but if this is not possible,corm trimming to reduce egg and larval numbers must be practiced); clearing the plantations of rotting vegetation so as to remove habitats suitable for harbouring the pest; cutting off old pseudostems at soil level and covering the cut rhizome with soil, which is said to prevent the weevil's entry and deter oviposition; chopping up and scattering old stems so that they quickly dry off and do not attract the pest; regular desuckering; and good weed control.

Trapping of the migratory adults can be done by carefully placing cut pseudostems in strategic locations with the cut surface downwards and collecting the insect by hand once a week.

Certain banana cultivars apparently exhibit resistance to some degree but no commercial cultivar possess this highly desirable characteristic to any useful extent.

Before planting, clean trimmed suckers should be dipped into a solution of persistent soil insecticide. The techniques of dipping vary widely ranging from 10 mins-24 hours dipping in solutions of 0.1-0.4% aldrin, dieldrin, chlordane and even a clay/endrin emulsion. Dusting the holes prior to planting with a powder formulation of these organo-chlorine materials is also useful and it is attractive to small growers who lack dipping facilities.

Field treatment of infested plants can be made about 30 days after planting and repeated at regular intervals; this schedule should be based on the result of trap counts. The chlorinated hydrocarbons are again the most widely recommended insecticides but reluctance to use these products in the past decade because of high persistency in the soil and development of resistance has led to investigations into the suitability of other chemicals. Carbofuran, dichlorvos, and pirimiphos-ethyl are some of the alternative chemical weapons against the banana weevil. Applications as sprays or granules of these materials must be made to the base of the plant in order to prevent the approach of female egg layers and the emergence of new adults from the pupal chambers.

Tuber Rot of Yams

I have tentatively identified the tuber rot of yams as being caused by Botryodiplodia theobromae, a common disease in tropical areas which also causes rots of sweet potato and cassava tubers. Identification should be confirmed through isolation and culture of the fungus.

The symptoms clearly indicate that infection starts from wounded areas of the tuber, and in this case from extensive injury made by a tunneling insect pest. The insect pest itself was not present in the stored infected tubers but the shape and size of galleries indicate that it is most likely a grub (Coleoptera:-Scarabaeidae), or possibly a weevil (Coleoptera:Curculionidae).The tissues lining the tunnels turn black, with the rot radiating out, sometimes in finger-like projections. The diseased tissue seems to initially turn grey-dirty in colour and moist in appearance. It later turns black, and loss of moisture results in the tissue becoming hardened, the bark sloughing off in flakes.

The symptoms just described constitute only a scant and static description of symptoms in time. Additional observations should be made through time which could better describe the disease's developmental phases and confirm its identification.

Control should primarily consist of prevention of insect pest damage and careful handling of tubers during harvesting and transportation to avoid any feeding injury or mechanical damage to the tissues. Other simple control measures include painting of cut surfaces with limewash or Bordeaux mixture and coating with a suspension of wood ashes. Curing at 30°C and 85-90% R.H. is popular, but storage temperature should be lowered to 12.5-15°C and a relative humidity of 85-90%. Storage chambers should be properly ventilated, to avoid accumulation of carbon dioxide, while at the same time keeping the proper storage temperature.

Smut of Sugarcane

Smut of sugarcane is caused by the fungus *Ustilago scitaminea.* It is generally widespread in sugarcane growing areas of the world. Losses in yield depend upon the incidence of the disease, the intensity of which is governed by the variety and environmental factors affecting spore dissemination and germination. Losses can be quite high; and are even higher in ratoon crops.

The disease's most patent symptom is the production of a whip-like structure from the apex of the plant, which consists of a hard core surrounded by a thick layer of chlamydospores. The whip is initially covered with a thin milky-coloured membrane, which later ruptures liberating the spores which become airborne.

Primary infection occurs from a diseased seed piece. The disease is systemic as clipping the whip off causes side buds to sprout, which also bear a smut whip. Diseased plants can be detected before the appearance of the whip through symptoms of early tillering, thin and grass-like shoots with long internodes, and narrow leaves that remain stiff at an acute angle.

No effective control measure exists as yet. However, disease incidence can be reduced by using one or more of the following measures: (1) planting of healthy setts; (2) removal of smutted whips – the affected clumps should be removed before the emergence of the whip. In case the whips have emerged, these should be covered with a gunny bag first and then removed; (3) discouraging ratooning of diseased crop; (4) planting only disease resistant varieties – sugarcane varieties having compact bud scales usually escape infection; and (5) disinfection of setts with organomercurials before planting, which helps destroy superficial smut inoculum.

Red Rot of Sugarcane

Red rot of sugarcane is an anthracnose disease caused by *Glomerella tucumanensis* (perfect stage) or *Colletotrichum falcatum* (conidial or imperfect stage). The disease most seriously affects the buds of the seed cane, the result of which are poor stands and consequently low yields.

The first external symptom is that the upper fully mature leaves of the plant wither at the tip and along the margins. Later on, the whole crown may wither and dry up. Symptoms on the leaves and sheaths are elongated reddish spots with a purplish to black center. Cutting the stem longitudinally shows a reddening of internal tissues with white spots usually elongated at right angle to the stem.

The annual recurrence of the disease is primarily through infected cane seed and secondary spread of the the inoculum through rain.

Control is difficult if not impossible to achieve once the disease has appeared. However, the disease can be prevented by eliminating the fungus from the seed material by the hot air treatment and can be reduced by taking precautions such as (1) procurement of seed from healthy setts; (2) systematic roguing of diseased clumps throughout the season; (3) discouraging ratooning of diseased crop; and (4) practicing a 2 to 3 year crop rotation.

Cashew Anthracnose

Cashew anthracnose caused by *Glomerella cingulata* is a very destructive disease of cashew (*Anacardium occidentale*). Its most serious effect seems to be the destruction of the flower sets, resulting in little or no fruit production. This disease appears to be common throughout Haïti and to cause a lot of grief among Haïtian peasants, as the trees, on the whole, appear healthy and bear heavy flower sets, thus bringing the unfullfilled promise of a bountiful harvest.

Unfortunately, I was not able to find in the literature readily at hand much information about this disease. FAMV's plant pathologist, Dr. Jean Vernet Henry, claims that this disease is in fact a complex of diseases, of which anthracnose is one. Breeding programs for resistance were apparently under way in Haïti some years ago but were practically abandoned due to political events (Dr. Henri Turenne, Service de Protection des Végétaux, Damien; pers. comm.).

C. RECOMMENDATIONS

Recommendation # 1: That, for the purpose of implementation of a new cropping system, further surveys be conducted to repertoriate the insect pests and diseases of corn and assess their populations or incidence, with and without stubble burning. Likewise, population monitoring of rats should be carried out and their damage assessed, both under current agronomic practices and under the proposed new cropping system's practices. Contingent to the evaluation of the nature of the pest problems and the value and the needs for control, methods of control could then be studied and implemented as an integral part of the proposed new cropping system. A preliminary literature search could help define the scope of such a study by finding out how similar situations have been approached elsewhere. I estimate the literature search, reading and synthesis could take up to seven days of work.

Recommendation # 2: That further literature searches be conducted on the pest insects and diseases that have been identified so far. The more recent literature may contain new and useful information on their dynamics and methods of control. For example, I know for a fact that much has been published of late on the sweet potato weevil. Likewise, I expect that more has been published on the diseases surveyed, especially as regards advances in breeding for resistance. The concerned breeding centers could then be contacted to obtain resistant cultivars that could be tested under Haïtian conditions. I estimate a further 3 days would be needed to complete this literature search for the purpose of updating the cursory literature review that I carried out herewith.

APPENDIX IV.

ITINERARY

Date		Activities
Feb. 1/Sun.	0755	Departed Vancouver.
	1630	Arrived Montreal.
Feb. 2/Mon.		Went to Haïti Embassy in Montreal to obtain visa.
Feb. 8/Sun.		Travelled to Quebec City. Briefed by Michel Cusson.
Feb. 9/Mon.		Travelled to Montreal.
Feb. 16/Mon.	1100	Departed Montreal.
	2030	Arrived Port-au-Prince.
Feb. 17/Mon.	1100	Registration at Canadian Embassy.
	1200	Briefed by Jim Talbot and Dick Pellek.
	1400	Briefed by A. Hunsberger, L. Bergner, A. Unda, and D. Pellek at the PADF offices in Port-au-Prince.
	1700	Reclaimed baggage at airport.
Feb. 18/Tues.	0800	Briefed by R. Wilson, I. Lowenthal, and D. Pellek at USAID Mission.
	1100	Reclaimed baggage at airport.
	1400	Travelled to Vialet. Introduced to nurseryman at the Vialet Nursery.
	1600	Travelled to Jacmel. Overnight in Jacmel.
Feb. 19/Wed.	0800	Travelled to Bainet and surveyed nursery.
	1300	Travelled to Port-au-Prince.
Feb. 20/Thur.	0800	Travelled to Fermathe and surveyed Baptist Nursery.
	1300	Travelled to Port-au-Prince and spent rest of afternoon working at USAID Mission.
Feb. 21/Fri.		Rested in morning and afternoon. Read literature pertaining to assignment in the evening.
Feb. 22/Sat.		Spent day reading literature.
Feb. 23/Mon.	0700	Spent morning at USAID Mission preparing for week of field trips.
	1100	Travelled to Les Cayes.
	1500	Briefed by Mr. Gaspard Brice.
	1600	Spent rest of afternoon and evening reading literature.
		Overnight in Les Cayes.

Feb. 24/Tues. Spent day in the field visiting nurseries (DRE in Les Cayes, DCCH in Laborde, and ORE in Camp Perrin) and filling out Nursery Profile questionnaires with nurserymen.
Overnight in Les Cayes.

Feb. 25/Wed. Spent day surveying previously mentioned nurseries for pest insects and diseases. Spent evening reading literature and writing up report.
Overnight in Les Cayes.

Feb. 26/Thur.	0630	Travelled to Port-au-Prince.
	1100	Presented preliminary results at the PADF Staff Meeting and made rendez-vous with PADF's regional team leaders for visiting their nurseries.
	1500	Spent rest of afternoon working at USAID Mission.
Feb. 27/Fri.	0800	Travelled to Damien and was briefed by Tobey Pierce. Tried to visit laboratory facilities and to meet plant protection personnel but without success.
	1330	Travelled to Port-au-Prince and spent rest of afternoon working at USAID Mission.
Feb. 28/Sat.	0800	Travelled to Vialet.
	1000	Surveyed Vialet Nursery.
	1200	Travelled to Port-au-Prince.
	1400	Spent rest of day resting.
March 1/Sun.	0800	Reviewed literature and worked on insect collection.
	1200	Spent rest of day resting.
March 2/Mon.	0700	Prepared for field trips and reviewed literature.
	1200	Spent several hours looking for a jeep to rent.
	1400	Travelled to Cap Haïtien. Overnight in Cap Haïtien.
March 3/Tues.	0900	Briefed by Mr. Ralph Mathieu, team leader, (NE).
	1000	Travelled to Riviere Salee and surveyed nursery.
	1200	Travelled to Limbe and surveyed the Hopital Bon Samaritain's nursery.
	1800	Travelled to Cap Haïtien. Overnight in Cap Haïtien.

March 4/Wed. Spent day resting.

March 5/Thur.	0700	Travelled to Pignon.
	1100	Met John Jickling, team leader (Plateau Central), and surveyed nursery.
	1300	Travelled to Thomonde.
	1500	Surveyed Thomonde nursery.
	1730	Travelled to Port-au-Prince.

March 6/Fri. 0900 Spent morning having jeep fixed (back window had smashed in the night before while travelling back to Port-au-Prince due to both bad road and jeep condition.
1400 Spent afternoon at USAID Mission identifying plant diseases.

March 7/Sat. Spent afternoon gearing up for trip to NW. Read literature.

March 8/Sun. 1100 Travelled to Gonaïves. Overnight in Gonaïves.

March 9/Mon. 0800 Jeep repair.
0900 Briefed by Peter Welle, team leader, and Marcia McKenna, forester, at CARE offices in Gonaïves.
1030 Travelled to Passe-Catabois.
1530 Surveyed Passe-Catabois forest tree nursery.
Overnight in Passe-Catabois.

March 10/Tues. 0800 Surveyed Passe-Catabois fruit tree nursery.
0930 Surveyed Women's Association tree nursery near Passe-Catabois.
1030 Surveyed a fruit tree outplanting site in the Passe-Catabois region.
1100 Travelled to Jean Rabel.
1300 Surveyed Jean Rabel nursery.
1400 Travelled to Baie de Henne. Overnight in Baie de Henne.

March 11/Wed. 0800 Fixed jeep (cleaned spark plugs).
0900 Travelled to Desforges.
1230 Surveyed Desforges nursery.
1330 Travelled to Bombardopolis.
1430 Surveyed Bombardopolis nursery.
1600 Insect and Herbarium collection maintenance.
Overnight in Bombardopolis.

March 12/Thur. 0800 Fixed jeep (cleaned spark plugs).
0900 Travelled to Baie de Henne.
1100 Surveyed Baie de Henne nursery.
1300 Travelled to Gonaïves. Overnight in Gonaïves.

March 13/Fri. 0800 Fixed jeep (replaced spark plugs).
1000 Travelled to Port-au-Prince.
1400 Had jeep fixed at car rental company.

March 14/Sat. Spent the day resting.

March 15/Sun. Spent morning reviewing literature.

March 16/Mon. 0800 Fixed jeep (battery connections).
1000 Worked at USAID Mission.
1630 Met Jerry Grosenick, economist with U. of Maine, and surveyed post-harvest insect pest problems in logs of AOP tree species stored in his backyard.

March 17/Tues. 0800 Travelled to Damien.
0900 Met Mr. Fenel Felix. Had to arrange letter of introduction to the Dean of the Faculty before I could meet the entomologist and plant pathologist and use lab facilities.
1000 Returned to Port-au-Prince.
1100 Worked at USAID Mission for the rest of the day.

March 18/Wed. 0630 Travelled to Mirebalais with Dean Treadwell.
0830 Met Jocelyn Paul, assistant to Stuart North, team leader (Plateau Central South) and surveyed Mirebalais nursery.
1130 Travelled to Desvarieux.
1230 Surveyed Desvarieux nursery.
1330 Travelled to Maissade.
1600 Insect and Herbarium collection maintenance.
Overnight in Maissade.

March 19/Thur. 0900 Travelled to Mme Joa.
1000 Surveyed insect pest and diseases of peasants' agricultural crops.
1230 Travelled to Maissade.
1400 Debriefed with Andy White, project leader, Maissade Watershed Management Project, Save the Children Fund.
1500 Travelled to Port-au-Prince.

March 20/Fri. 0800 Travelled to Damien.
0900 Met Mr Jean Vernet Henry, plant pathologist, and discussed tree diseases.
1200 Carried out nematode extraction on previously collected soil samples.
1400 Travelled to Port-au-Prince.
1500 Spent rest of day working at USAID Mission.

March 21/Sat. 0900 Travelled to Damien.
1000 Completed nematode extraction.
1200 Travelled to Port-au-Prince
1300 Returned jeep and looked around for renting a car.
1700 Worked on report till late evening.

March 22/Sun. Worked on report all day.

March 23/Mon. 0800 Travelled to Damien.
0900 Met Mr. Bertrand Derouilleres, entomologist, and discussed insect pest problems in agroforestry tree nurseries and outplantings.
1300 Returned to Port-au-Prince and worked on report at USAID Mission.

March 24/Tues. Worked on report all day at USAID Mission.

March 25/Wed. Worked on report all day at USAID Mission.

March 26/Thur. 0900 Travelled to Les Cayes.
1330 Debriefed at PADF Technical Retreat meeting.
1500 Travelled back to Port-au-Prince.

March 27/Fri. 0830 Debriefed at USAID Mission.
1100 Worked on report for the rest of the day at USAID Mission.

March 28/Sat. Rested in the morning.
Spent afternoon trying to recover report files and word processing program from damaged disks.
Worked on report in the evening.

March 29/Sun. Worked on report all day.

March 30/Mon. Worked on report all day.

March 31/Tues. Worked on report at USAID Mission.
1600 Debriefed with Mr. Ira Lowenthal.
Packed up in the evening.

April 1/Wed. 0700 Departed Port-au-Prince.
1830 Arrived Vancouver.

APPENDIX V.

LIST OF CONTACTS

USAID/Haïti (Port-au-Prince)

Dr. James J. R. Talbot
Dr. Richard R. Pellek
Mr. Ira Lowenthal
Mr. Robert J. Wilson
Mr. Dean Treadwell

PADF

Mr. A. Hunsberger
Mr. Louis Bergner
Mr. Alfredo Unda
Mr. Stuart North
Mr. John Jickling
Mr. Ralph Mathieu
Mr. Gaspard Brice

CARE

Mr. Rick Scott
Mr. Peter Welle
Ms. Marcia McKenna-St. Jean

Faculté d'Agronomie, Université d'Haïti, Damien

Dr. Felix Fenel, phytologiste
Dr. Jean Vernet Henry, phytopathologiste
Dr. Bertrand Derouillères, entomologiste

DARNDR

Mr. Tobey Pierce

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