PD-ABD-282

# SECID

The South-East Consortium for International Development

400 Eastowne Drive • Suite 207 • Chapel Hill • North Carolina 27514

PD-ABD-282
73841

Final Report

Seychelles Food Crops
Research Project

Contract No.
AFR-0001-C-00-1032

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# Final Report of the Seychelles Food Crops Research Project

## I. Introduction

An evaluation of the Seychelles Food Crops Research Project was performed in February 1984, only six weeks before termination of the project on March 31, 1984, and therefore the report of that evaluation, the Evaluation and Completion Report, was written as a project completion report. We feel that this was a good report of the status of the project, and will refer to it here rather than repeat the information contained therein. This Final Report will be somewhat similar to the Evaluation and Completion Report, the primary difference being that the Evaluation and Completion Report dealt with the overall project design, goals, and accomplishments, whereas we deal here with those subjects from the contractor's point of view. We will up-date project status where activities have been completed. We assume familiarity with the basic structure of the project and project documents.

## II. Objectives

The South-East Consortium for International Development (SECID) signed a three-year contract effective April 1, 1981 with the U.S. Agency for International Development to provide technical assistance and training in food crops research to the Ministry of Agriculture, Government of the Seychelles.

The objectives of the project, as stated in the contract, were "to expand and strengthen the capability of the Government of the Seychelles, Department of Agriculture and Land Use to (1) conduct applied and adaptive food crops research, (2) extend proven results of such research to small holder farmers, and (3) protect the agricultural sector from the introduction of pests and diseases from abroad."

## III. Personnel

Three long-term technicians and one consultant provided the technical assistance, and a Home Office Staff composed of a Project Coordinator, a Home Campus Coordinator, clerical and financial support provided back-stopping. All personnel associated with the project, and their dates of service are as follows:

Field Staff

Dr. Richard Wurster, COP, Horticulturist, SECID, April 81-September 83

Dr. Graydon Kingsland, Plant Pathologist, Clemson University, July 81 - December 82; February 84 - March 84

Dr. Wayne Sitterly, Plant Pathologist, Clemson University, January 83 - January 84

Dr. Thomas Cochrane, Soil Scientist, SECID, October 81-February 82; July 83 - September 83

Dr. Garnet Craddock, COP, Soil Scientist, Clemson University, September 83 - March 84

Dr. Merle Shepard, Entomologist, Clemson University, July 81 - September 81; June 82 - August 82; May 83 - July 83

AID

Mr. Dominick Scarfo, Project Director, REDSO/ESA, April 81 - March 84

GOS

Mr. Cliff Adam, Project Director, April 81 - March 84

Home Office

Dr. Elsa Liner, Project Coordinator, SECID, April 81 - March 84

Dr. George von Tungeln, Home Campus Coordinator, April 81 - March 84

Dr. Wurster was originally scheduled to terminate his assignment March 31, 1984, but he was removed September 16, 1983 at the request of the American Ambassador. SECID was prepared to recruit a replacement Horticulturist, but

REDSO decided that this was not needed. It was felt that there was not sufficient time remaining in the project for a new horticulturist to make an impact on the horticultural activities.

Although Mr. Adam remained as GOS Project Director for the duration of the project, his outside responsibilities were increased over the life of the project resulting in a decrease of GOS support for project activities.

At the beginning of the project Mr. Adam was Chief Research Officer (CRO), Ministry of Agriculture, with principal responsibility for Grand Anse Experiment Station. Over the course of the project, the GOS was reorganized, with decreasing importance placed on agriculture. The Ministry of Agriculture was dissolved and reorganized under the Ministry of National Development. Later Mr. Adam's position was changed from CRO to Director of the Department of Agriculture Promotion, which includes Forestry, Livestock, Control, Services, and Crops (Research). The Chief Extension/Pest Control Officer who functioned as counterpart for the project Entomologist left the Ministry and his position was not filled. Another reduction in agriculture personnel occurred when the Peace Corps Volunteers, originally a major part of the extension effort, withdrew and were not replaced by agriculture personnel. This lack of support for agriculture on the part of the GOS decreased the effectiveness of project activities near the end of the project.

Although not included in the contract, a consultancy by Dr. Roger Ginder, an Agricultural Economist, was funded through a TSM with REDSO for a two month assignment beginning in October 1982 to work on pricing policy for vegetable crops. He prepared two reports for the MOA and presented a seminar on his work for personnel of the MOA at Grand Anse Station on November 12, 1982.

## III. Major Events

The following is a schedule of the major events that took place during the Food Crops Research Project. For detailed information on these events, the reader is referred to the Project Quarterly Reports. A summary of the Quarterly Reports is appended to the Evaluation and Completion Report. These may also prove useful.

| | |
|---|---|
| Contract between AID and SECID signed effective | 4/81 |
| Logistical visit (2 mo) COP/Horticulturist (Wurster) | 4/81 |
| Contract Personnel arrived - Horticulturist and Plant Pathologist (Wurster and Kingsland) | 7/81 |
| Short-term (2 mo) visit of Entomologist (Shepard) | 7/81 |
| Soil Scientist (Cochrane) arrived | 10/81 |
| Site visit by Project Coordinator (Liner) | 10/81 |
| Soil Scientist (Cochrane) departed | 2/82 |
| Short-term Entomologist visit (Shepard) (2 mo) | 6/82 |
| Technicians sent for 10 week training course at Clemson | 5/82 |
| Site visit by Project Coordinator (Liner) and Home Campus Coordinator (von Tungeln) | 2/82 |
| Short-term Entomologist visit (Shepard) (2 mo) | 6/82 |
| Disruption because of army coup attempt | 7/82 |
| COP/Horticulturist (Wurster) and Pest Control Officer (Young) attend International Society of Horticulure Meeting in Hamburg | 8/82 |
| Agricultural Economist visit (Ginder) (2 mo) | 10/82 |
| MOA dissolved, Ministry of National Development formed | 11/82 |
| Departure of Plant Pathologist (Kingsland) | 12/82 |
| Arrival of Plant Pathologist (Sitterly) | 1/83 |
| Audit Report by Inspector General's Office (Marr) | 2/83 |
| Site visit by Project Coordinator (Liner) and Home Campus Coordinator (von Tungeln) | 2/83 |
| Lab construction started | 3/83 |

| | |
|---|---|
| Farm Manager of GAC (Chung) sent on study tour | 8/83 |
| Short-term Entomologist visit (Shepard) (2 mo) | 6/83 |
| Ninth African Symposium of the International Society of Horticulture Science | 7/83 |
| Short-term (2 mo) visit by Soil Scientist (Cochrane) | 7/83 |
| GAC Agriculture Officers, counterparts (Johnson and Moustache,) arrived in Seychelles | 9/83 |
| Horticulturist (Wurster) removed | 9/83 |
| Arrival of Soil Scientist/COP (Craddock) | 9/83 |
| Soil/Plant Pathology Laboratory operational | 10/83 |
| Departure of Plant Pathologist (Sitterly) | 1/84 |
| Arrival of Plant Pathologist (Kingsland) | 2/84 |
| Evaluation & PCR performed (Harris and Faught) | 2/84 |
| Site visit by Project Coordinator (Liner) to close down project | 2/84 |
| Departure of Soil Scientist and Plant Pathologist (Craddock and Kingsland) | 3/84 |

## V. Technical Assistance

The contract called for the team members to write an Implementation Plan laying out a research program. This was a collaborative effort by Dr. Wurster, Dr. Kingsland, Dr. Cochrane, and Dr. Shepard.

### A. Horticulture

A summary of the responsibilities of the project Horticulturist as stated in the contract is as follows:

- assist planning, designing and conducting variety trials of at least 200 vegetable and fruit cultivars;
- train and collaborate with Seychelles staff on research design and methodology;

- train GAC personnel to observe trials and collect data;
- assist in establishing an indexing system for all food crop introductions;
- assist in multiplying adaptable varieties for distribution of seeds and cultivars to small farmers;
- in collaboration with the Chief Research Officer assure operation and maintenance of soils analysis laboratory following departure of Soil Scientist;
- assist in arranging farmers' field days for the transfer of the research results;
- assist in demonstrations of improved farming practices;
- assist the GAC staff and extension service in preparing teaching materials and bulletins on horticultural topics;
- collaborate with CRO on requirements for equipment and supplies needed for horticultural research;
- assist GAC in establishing linkages for information exchange with international research centers and agricultural stations in Indian Ocean;
- assist GAC in organizing and hosting a conference to share results of GAC's research program;
- travel among islands of Seychelles as required;
- assist in planning three training and orientation programs for CRO;
- present lectures to FTC students and extension service personnel;
- assist GAC in establishing a technical library in horticulture;
- work with Peace Corps Volunteers in research and extension activities; and
- prepare formal and informal reports.

A report of the work accomplished by the Horticulturist can be found in the Quarterly Reports or the summary of Quarterly Reports appended to the Evaluation and Completion Report. Briefly, the Horticulturist performed over 159 variety trials at GAC and regional sites on vegetables including cabbages, tomatoes, sweet peppers, and potatoes from Taiwan, Peru, Florida, Puerto Rico, and Kenya. Records of results were not reported for the trials, but it must be remembered that Dr. Wurster was terminated unexpectedly seven months earlier than scheduled. Presumably his work would have been more complete had he served out his full tour. Dr. Wurster trained agriculture personnel in planting and recording data from field trials. A modification of the indexing system used in Kenya for new introductions was instituted in early 1983. All other tasks specified in the contract were accomplished. Special mention should be made of the Ninth Meeting of the African International Society of Horticultural Science held in the Seychelles in July 1983 and sponsored by the project. Co-conveners were Dr. Wurster, Mr. Cliff Adam, and Mr. Antoine Young. The first international agriculture meeting ever held in the Seychelles, this served to disseminate the work of the project and to establish professional ties between the Seychelles and other agricultural research programs in the area. A program from the meeting can be found in Appendix 1.

B. Plant Pathologist

A summary of the responsibilities of the Plant Pathologist is as follows:

- assist GAC staff in establishing a modest laboratory;
- train Seychelles counterpart, holder of B.S. in Agriculture;
- train two Seychelles technicians, holders of "A" level certificates;
- assist in overseeing construction of small screen house;
- in collaboration with GAC staff undertake series of surveys of food crop diseases;

- prioritize diseases which require additional study;
- in collaboration with Horticulturist and Soil Scientist implement a crop protection program;
- identify sources of resistance in local and imported cultivars based on trials at GAC;
- train GAC scientist to determine the effects that planting dates and rogueing of infected plants have on disease spread and intensity;
- advise on introduction of clean plant materials;
- plan detailed short-term training programs in plant protection for Seychelles counterpart;
- plan short-term training programs for plant quarantine staff;
- assist GAC in establishing a technical library;
- present lectures in plant protection;
- participate in farmer's field days;
- advise in preparing bulletins on plant diseases;
- train extension personnel;
- prepare reports; and
- travel among islands of Seychelles as required.

For a detailed account of the achievements of the Plant Pathologists, the reader is referred to Dr. Kingsland's and Dr. Sitterly's End of Tour Reports shown in Appendix 2, the Quarterly Reports, and the Evaluation and Completion Report. Briefly, they have fulfilled all the requirements of the contract. They were not able to train their Seychellios counterpart, Mrs. Yacintha Johnson, to the level they would have liked because she did not return to Seychelles from the University of the West Indies until September 1983. The Plant Pathologists worked very closely with GAC personnel in designing and equipping the Soils/Plant Pathology lab, although this facility was planned

after the contract was written. At the time of the Evaluation and Completion Report construction had not begun on the screenhouse. Since that report, the screenhouse has been completed. The Plant Pathologists have prioritized many diseases, and studied them intensively. Dr. Kingsland has even found a new disease never before reported. He will be publishing several articles in profesional, refereed publications on this disease and others he worked on in the Seychelles. A color handbook in English, which will be translated into Creole, has been produced by the Plant Pathologists and Entomologist for use by farmers and GAC personnel. A copy is attached in Appendix 3. In addition, Dr. Sitterly helped SEYCOM develop a grading system for local produce.

C. Entomologist

The duties of the Entomologist are summarized as follows:

- collaborate with GAC personnel in conducting a survey of insect and mite pests on food crops;
- identify insect and mite vectors of food crop diseases;
- collaborate with team in developing applied research program for insect and mite pests;
- assist Plant Pathologist in testing transmission of important food crop viruses;
- collaborate in developing integrated pest management system to control disease;
- collaborate with GAC staff in designing and conducting trials;
- recommend procedures for controlling food crop pests;
- prepare reports; and
- travel among islands of Seychelles, as required.

The reader is referred to Dr. Shepard's End of Tour Reports (Appendix 4) for details of his accomplishments. He has fulfilled all the requirements

listed above, and has worked closely with the Plant Pathologists to develop the handbook on plant and pest diseases.

D. Soil Scientist

A summary of the Soil Scientist duties are as follows:

- assist GAC staff in establishing modest soils laboratory;
- train a Seychellois technician holding B.S. degree;
- assist in undertaking a general survey of fertility;
- select suitable soil testing methods;
- assist in establishing a soil and plant testing program;
- assist with classifying soils of Seychelles;
- collaborate with CRO and Horticulturalist on field trials;
- collaborate with GAC on designing research program;
- collaborate with GAC, CRO, and Plant Pathologist in designing trials on nitrogen fixation;
- plan training program for Seychelles counterpart;
- assist GAC in establishing a library;
- collaborate with extension service on dissemination of soil research results;
- present lectures on soil management;
- participate in farmers' field days;
- assist in demonstrations at GAC, state farms, FTC and farmers' plots;
- assist in preparing bulletins;
- prepare reports; and
- travel among islands of Seychelles.

Dr. Cochrane and Dr. Craddock together fulfilled all the above requirements. Dr. Cochrane was most instrumental in designing the Soils Laboratory and setting it up for operation. Details are contained in the End of Tour Report in

Appendix 5. Like the Plant Pathologists, the Soil Scientists were unable to train fully their Seychelles counterpart, Mr. Antoine Moustache, because he did not return to the Seychelles from the University of the West Indies until September 1983. Both scientists worked on the soil survey of the Seychelles and Dr. Cochrane developed a classification system for soils. Dr. Craddock developed a laboratory manual of procedures for preparing and testing soil samples. He also drew up fertilizer recommendations for use by GAC and local farmers. The laboratory procedures and fertilizer recommendations appear in Appendix 6.

## VI. Training

The contract calls for 21 months of short-term training, 15 months in the U.S. and 6 months in third countries. In May 1982 a Horticulture research assistant, a Plant Pathology assistant, and a Soils Science assistant made a 10-week training tour to the U.S., primarily at Clemson University's main campus and its Coastal Experiment Station in Charleston, S.C. In August 1983 the Farm Manager made a one-month study tour to sites in Taiwan, Hawaii, South Carolina, Florida, and Puerto Rico. These study tours were under the direction of the Home Campus Coordinator, Dr. von Tungeln.

Throughout the project on-the-job training was provided by the team members for Seychellois technicians and counterparts. The problem with the late return of the Soil Scientist and Plant Pathology counterparts from the University of the West Indies and the departure of the Pest Control officer to work at SADECO has already been mentioned.

## VII. Home Office Support

### A. Home Campus, Project Management, and Backstopping Activities

Dr. George von Tungeln, of Clemson University, served as Home Campus Coordinator throughout the project. In this capacity he had responsibility for technical aspects of the project, recruiting, and training programs. Dr. Elsa

Liner, SECID, served as Project Coordinator, and was responsible for budgeting and financial management, logistics, and coordination between the field team, home office staff and team members on U.S. campuses. Together they provided overall project management. Committed to the success of this project, SECID funded a site visit to the Seychelles for the Project Coordinator in October 1981 in order to establish close contact between the Home Office and the field. Then in February 1982 an issue arose over the apropriateness of the project vehicle and its use. Because this matter seemed of such concern to the team, SECID sent the Project Coordinator and Home Campus Coordinator out to the Seychelles to settle this matter. It was decided that SECID would purchase this vehicle, a Mazda 626, from the project, and the project would then buy a pick-up. This course was followed, and the matter was resolved. Additional site visits by the Project Coordinator and Home Campus Coordinator were made in February 1983 and by the Project Coordinator in February 1984. These trips were funded by the project.

B. Financial and Budgetary Issues

An accounting of expenditures as of June 30, 1984 is shown in Appendix 7. At this time there remains $50,669.59 in unspent funds. At the request of the GOS the project paid for $35,605.05 worth of equipment and supplies for the Soils/Plant Pathology Laboratory so that they would be on hand in the Seychelles to be installed as soon as construction of the laboratory was completed. SECID billed the GOS in May 1982, contacted Mr. Cliff Adam about this matter in February 1984, and billed the GOS again in June 1984. This amount is still outstanding.

C. Issues and Accomplishments

We believe that the contract personnel have done a fine job, and have made significant progress in their areas of expertise. However, as noted above,

there was a decrease in GOS support for agriculture over the life of the project, and for that reason we have serious concerns about the long-lasting effect of the project. The factor with the greatest potential impact is the Soils/ Plant Pathology Laboratory. Counterparts were trained for only seven months rather than for the entire duration of the contract, as originally planned. While the counterparts were doing quite well, seven months is not long enough to see the full range of plant disease which can occur under various seasonal and growing conditions. We believe that further in-country training for these counterparts and other technicians to backup Mr. Moustache and Mrs. Johnson is a top priority for the laboratory to achieve its full potential.

A second solid accomplishment which we leave behind is the handbook on plant and pest diseaseS. Written in English, to be translated into Creole, this should prove beneficial to GAC staff and local farmers in diagnosing and treating their crops.

Finally, the activity which probably has the most long lasting effect in any project is training. It is unfortunate that no more of the overseas training available under the project was used, and that counterparts were not present throughout the project. However, technicians and assistants received on-the-job training over the life of the project, and this will certainly pay dividends in the long run.

The next step in agriculture in the Seychelles would be funding for a continued research program. Particular emphasis should be put on entomology and pest control since this area did not receive sufficient funding under our project. There is not a sufficient number of adequately trained personnel to mount a research program without outside help. This situation is likely to be true for at least the medium term. In conjunction with the research program, a major training program should be designed to ensure that appropriate personnel will be

available to carry on the research effort after the termination of donor funding. Also as part of this effort an Extension Service should be organized and staffed to transfer the results of the research program to farmers.

Finally, agriculture in Seychelles could benefit from outside input on pricing policy and grading systems for fruits and vegetables. Dr. Sitterly and Dr. Ginder began this work, but a much greater effort must be made to have any real impact.

APPENDIX 1: Program from ISHS Meeting, July 1983

# NINTH AFRICA HORTICULTURAL SYMPOSIUM

Mahe - Seychelles

July 27 — 29, 1983

# I S H S NINTH AFRICA HORTICULTURAL SYMPOSIUM

## Mahe, Seychelles

## July 27 — 29, 1983

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## OPENING

**Wednesday, July 27, 1983, 9.00 a.m.**

| | | |
|---|---|---|
| National Anthem | | |
| Official opening | — | Government of Seychelles |
| Welcome to delegates | — | Mr. C. S. Adam, Director, Agricultural Promotion, Symposium convenor. |
| International Society for Horticultural Science, Organization and goals | — | Prof. H. D. Tindall Chairman, Commission for Tropical and Sub-tropical Horticulture, ISHS |
| Greeting | — | Hon. D. Fischer American Ambassador, Victoria |
| Role of FAO | — | Mr. W. O. Baudoin F.A.O. **Rome** |

Coffee Break—9.45—10.00

## Wednesday, July 27, 1983

**Morning Session**

Section A: Fruit Crops

Panel: C. S. Adam, J. Ddungu, H. M. E. Herath, K. Waithaka

10:00—10:15 1. Introduction, evaluation and development of tropical fruits in Seychelles.
C. S. Adam, **Seychelles.**

10:20—10:35 2. Tropical fruit research in Sri Lanka
H. M. E. Herath, **Sri Lanka.**

10:40—10:55 3. The factors which limit banana production in Buganda.
J. C. M. Ddungu, **Uganda.**

11:00—11:15 4. Mango growing in Coast Province of Kenya.
K. M. Kegga, **Kenya.**

11:20—11:35 5. Research program of IRFA on tropical and temperate fruits in Reunion.
B. Moreau and C. Vuillaume, **Reunion.**

11:40—11:55 6. Grapefruit production and problems in Somalia.
A. H. Mohammed, **Somalia.**

12:00—13:00 — Lunch.

## Wednesday, July 27, 1983

### Afternoon Session

Section A: Fruit Crops

Panel: H. D. Tindall, C. Arnold, F. Martin, J. Mukiibi.

| | | |
|---|---|---|
| 13:00—13:15 | 1. | The selection of citrus, stone and pome fruits for varietal improvement in Reunion.<br>A. Bernard, **Reunion.** |
| 13:20—13:35 | 2. | The performance of subtropical and temperate fruits in the Southern Highlands of Tanzania.<br>A. Nyomora, **Tanzania.** |
| 13:40—13:55 | 3. | Adaptation of peaches to high altitude tropical conditions in Reunion.<br>P. Fournier and B. Aubert, **Reunion.** |
| 14:00—14:15 | 4. | Peach culture under tropical conditions in Reunion.<br>P. Fournier, **Reunion.** |
| 14:20—14:35 | 5. | Decidious fruit cultivar evaluation in Malawi.<br>D. N. Tembwe and C. Arnold, **Malawi.** |
| 14:40—14:55 | 6. | Growth performances of everbearing strawberries in Kenya.<br>K. Waithaka, **Kenya.** |
| 15:00—15:15 | | Coffee Break. |
| 15:20—15:35 | 7. | The Interrelationship between Indolebutyric Acid (IBA) and endogenous soluble carbohydrate on the rooting of purple passion fruit, *Passiflora edulis* (Sims), stem cuttings.<br>F. M. Itylua, **Kenya.** |
| 15:40—15:55 | 8. | Fruit trees for agroforestry.<br>P. A. Huxley, Nairobi, **Kenya.** |
| 16:00—16:30 | | OPEN DISCUSSION ON FRUIT CROPS. |

## Thursday, July 23, 1983

### Morning, Concurrent Session I

Section B: Vegetable Crops.

Panel: I. Rajkomar, H. D. Tindall, R. Michellon, A. S. Abubaker.

| | | |
|---|---|---|
| 8:00—8:30 | 1. | Recent advances in the vegetable industry in Seychelles.<br>C. S. Adam and R. T. Wurster, **Seychelles.** |
| 8:40—8:55 | 2. | Goal—directed research on the tomato at the Mauritius Sugar Industry Research Institute.<br>N. Govinden, **Mauritius.** |
| 9:00—9:15 | 3. | The effect of spacing and phosphorus fertilizer levels on dry matter accumulation and fruiting of sweet peppers.<br>D. K. Mwamba, **Kenya.** |
| 9:20—9:35 | 4. | Vegetable production in Zanzibar.<br>S. Moll and K. J. Schroeder, FAO/**Zanzibar.** |
| 9:40—9:55 | 5. | Regeneration potential, leaf and seed yield of vegetable amaranth, *A. cruentus,* as a function of initial decapitation heights.<br>N. A. Mnzava, A. M. Masam, T. Ntimbwa and N. M. N. Mollei, **Tanzania.** |
| 10:00—10:15 | | Coffee Break. |
| 10:20—10:35 | 6. | Vegetable research in Zambia with emphasis on leafy vegetables.<br>I. Nkhungulu and W. Msikita, **Zambia.** |
| 10:40—10:55 | 7. | Selection and planting density of early yielding leafy vegetables.<br>K. F. Lan Chow Wing and I. Rajkomar, **Mauritius.** |
| 11:00—11:15 | 8. | Identification and nutritional importance of indigenous green leaf vegetables in Kenya.<br>J. A. Chweya, **Kenya.** |
| 11:20—11:35 | 9. | Asparagus production in Lesotho.<br>M. Petlane, **Lesotho.** |
| 11:40—11:55 | 10. | The effects of differential watering at various development stages on the production of snap beans.<br>K. M'Ribu, **Kenya.** |
| 12:00—13:00 | | Lunch. |

## Thursday, July 28, 1983

### Afternoon, Concurrent Session I

Section B: Vegetables Crops.

13:00—13:35 1. Selection of garlic cultivars in Reunion.

R. Michellon and J. L. Marchand, **Reunion.**

13:20—13:35 2. Selection and storage of onion cultivars.

I. Rajkomar, **Mauritius.**

13:40—13:55 3. Effect of ethrel applied to different types of planting materials at different stages of plant growth on vegetable growth and fruit production.

Y. Mwaule, **Uganda.**

14:00—14:15 4. Performance of a summer cauliflower cultivar in Mauritius.

I. Rajkomar, **Mauritius.**

14:20—14:35 5. Development of the vegetable industry of Comores.

B. Daoub and M. Scheltens, **Comores.**

14:40—14:55 Coffee Break.

## Thursday, July 28, 1983

### Afternoon Concurrent Session I

Section D: Tea, Coffee, Plantation Crops.

Panel: A. S. Abubaker, M. Magambo, J. M. Njoroge.

15:00—15:15 1 Growth and development of coconut palms and their relationship to fertilizer application.

A. S. Abubaker, **Kenya.**

15:20—15:35 2 Yields as affected by size of individual bushes and effect of pruning on dry matter production and yield of clonal tea.

M. Magambo, **Kenya.**

15:40—15:55 3. Effects of inorganic fertilizers on coffee yield and quality in Kenya.

J. M. Njoroge, **Kenya.**

## Thursday, July 28, 1983

### Afternoon Joint Session

16:00—16:30 — OPEN DISCUSSION:

Plant Protection.
Vegetable Crops.
Tea, Coffee, Plantation Crops.



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## Thursday, July 28, 1983

### Morning, Concurrent Session II

Section C: Plant Protection.

Panel: A. Young, J. Mukiibi, W. Sitterly, B. Aubert.

| | | |
|---|---|---|
| 8:00—8:15 | 1. | Alternaria leaf spot, a previously unreported disease of *Acalypha indica* L. (Euphorbiaceae).<br>G. Kingsland, USAID/SECID, **Seychelles.** |
| 8:20—8:35 | 2. | The nature and significance of transmission of *Isariopsis griseola* (Sacc) through seed of beans (Phaseolus vulgaria L).<br>R. A. Buruchara, **Kenya.** |
| 8:40—8:55 | 3. | Total phenolics in relation to late blight *Phytophthora infestans* resistance in potato varieties in Kenya.<br>M. N. Wabule, **Kenya.** |
| 9:00—9.15 | 4. | Progress on a fungicide evaluation system for Seychelles.<br>W. Sitterly, **Seychelles.** |
| 9:20—9:35 | 5. | Wet-rot complex of *A. cruentus:* Effects of plant density and nitrogen on directly sown plants.<br>N. A. Mnazava, A. M. Masam, T. Ntimbwa and N. M. N. Mollei, **Tanzania.** |
| 9:40—9:55 | 6. | Banana diseases in Uganda.<br>J. K. Mukiibi, **Uganda.** |
| 10:00—10:15 | | Coffe Break. |
| 10:20—10:35 | 7. | Pathogenicity and epidemiology of *Corynespora cassilicola* in the Seychelles.<br>G. Kingsland, USAID/SECID, **Seychelles.** |
| 10:40—10:55 | 8. | The effect of soil water potential on survival of *Xanthomonas campestris* in the soil.<br>J. M. Osando, **Kenya.** |
| 11:00—11:15 | 9. | Losses attributable to *Sclerotium rolfsii* on beans and tomato diseases in the Seychelles.<br>G. Kingsland, **Seychelles.** |
| 11:20—11:35 | 1o. | Bio-ecological data on *L. trifoli* and its parasite *B. semialbicalava.*<br>B. Vercambre and A. Thiery, **Reunion.** |
| 11:40—11:55 | 11 | The leaf miner *Liriomyza trifolii,* a new pest of potato and other vegetable crops in Mauritius.<br>H. Dove, **Mauritius.** |
| 12:00—13:00 | | Lunch. |

## Thursday, July 28, 1983

### Afternoon, Concurrent Session II

Section E: Plant Protection.

Panel: G. Kingsland, R.A. Buruchara, H. Dove, J. Mukiibi.

13:00—13:15 1. Seasonal and spatial distribution of the Mediterranean fruit fly on Mahe, Seychelles.

M. Shepard and A. Young, **Seychelles.**

13:20—13:35 2. Control of *Liriomyza trifolii* (Burgess) in beans *(Phaseolus vulgaris).*

B. Vercambre and A. Thiery, **Reunion.**

13:40—13:55 3. Biological control of the rhinoceros beetle.

C. J. Lomer, **Seychelles.**

14:00—14:15 4. Controll of bean Bruchids by the use of sunflower oil.

W. M. Mwathi, **Kenya.**

14:20—14:35 5. The population distribution of bean flower thrips in three agroecological zones in Kenya.

S. J. N. Muriuki, **Kenya.**

14:40—14:55 6. Reaction of some varieties of tomato to Meloidogyne spp.

S. T. Kanyagia, **Kenya.**

15:00—15:15 Coffee Break.

15:20—15:35 7. Weed control in onions.

E. B. O. Balah, **Kenya.**

15:40—15:55 8. The effect of weeds on growth and seed yield of beans.

E. B. O. Balah, **Kenya.**

## Thursday, July 28, 1983

### Afternoon Joint Session

16:00—16:30 — OPEN DISCUSSIONS:
Plant Protection.
Vegetable Crops.
Tea, Coffee, Plantation Crops.



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## Friday, July 29, 1983

### Morning Session

Section E: Root and Tuber Crops.

Panel: F. Martin, J. Kimani, C. S. Adam, M. D. S. Nzima.

8:00—8:30 1. Breeding tropical sweet potatoes: Vision, plans, methodology and progress.

F. Martin, **Puerto Rico.**

8:40—8:55 2. Intensification of sweet potato cultivation in Reunion.

R. Michellon, **Reunion.**

9:00—9:15 3. The effect of phosphorous fertilizer levels on growth of tuberous roots and vines of two sweet potato varieties.

K. Reshid and K. Waithaka, **Kenya.**

9:20—9:35 4. Light interception efficiency (Ei) conversion efficiency (Ec) and yield performance of IBA-treated basal vine cuttings and untreated terminal vines of sweet potato.

M. D. S. Nzima. **Zimbabwe.**

9:40—9:55 5. The performance of introduced potato varieties in Seychelles.

R. T. Wurster, USAID/SECID, **Seychelles.**

10:00—10:15 Coffee Break.

10:20—10:35 6. Root Crop research and production in Seychelles.

C. S. Adam, **Seychelles.**

10:40—10:55 7. Prospects of increasing potato production in Mauritius with clones introduced from CIP.

J. C. Audrey, P. Ferre, C. Ricaud, **Mauritius.**

11:00—11:15 8. Experience and results of potato evaluation in the lowland tropics of Africa.

J. Kimani, CIP/Nairobi, **Kenya.**

11:20—11:35 9. Effect of diseases and pests on the production of cassava and cocoyams.

J. M. Teri, **Tanzania.**

## Friday, July 29, 1983

### Morning Session

Section F: Horticultural Education, Extension and Marketing.

Panel: H. D. Tindall, G. Kingsland, Mr. W. O. Baudoin.

11:40—11:55 1. Horticultural education and extension in Tanzania.
R. D. Kyamba, **Tanzania.**

12:00—12:15 2. The marketing system of the horticultural crops in Kenya.
O. L. E. Mbatia, **Kenya.**

12:15—13:00 Lunch.

## Friday, July 29, 1983

### Afternoon Session

Section G: Nuts, Spice and Miscellaneous Crops.

Panel: A. S. Abubaker, I. M. G. Phiri, J. Ddungu, K. Waithaka.

13:00—13:15 1. Recent developments in the production of cashew nuts.
A. S. Abubaker, **Kenya.**

13:20—13:35 2. Field assay of the factors affecting macadamia performance in Malawi.
I. M. G. Phiri, **Malawi.**

13:40—13:55 3. The factors which affect the capsaicin content of chillies, *Capsicum frutencens.*
J. C. M. Ddungu, **Uganda.**

14:00—14:15 4. The effect of conventional methods of growing tea on yields.
M. J. S. Magambo and K. Waithaka, **Kenya.**



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## Friday, July 29, 1983

### Afternoon Session

Section H: General.

Panel: R. T. Opena, F. Martin, H. D. Tindall, C. S. Adam.

| | | |
|---|---|---|
| 14:20—14:35 | 1. | Cultivars adapted to tropical areas.<br>R. T. Opena, AVRDC, **Taiwan.** |
| 14:40—14:55 | 2. | Advances in horticultural production in Ethiopia.<br>Samu Negus - Haile Mariam, **Ethiopia.** |
| 15:00—15:15 | 3. | Horticultural production in Zimbabwe.<br>B. Parsons, **Zimbabwe.** |
| 15:20—15:35 | 4. | Evapotranspiration. Its influence on natural vegetation patterns and importance to crop introductions.<br>T. Cochrane, USAID/SECID, **Seychelles.** |
| 15:40—15:55 | 5. | Report on the progress of the IH/MSIRI drip irrigation project.<br>C. Batchelor, **Mauritius.** |
| 16:00—16:15 | 6. | Liatries forcing in Kenya.<br>K. Waithaka, **Kenya.** |
| 16:20—17:00 | — | OPEN DISCUSSION:<br>Root and Tuber Crops.<br>Horticultural Education Marketing.<br>Nut, Spice and Miscellaneous Crops. |
| 17:00—17:30 | — | Conclusions, recommendations and future plans. |
| 17:30 | | Closing. |

## ACKNOWLEDGEMENTS

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**The Symposium committee:**

Mr. C.S. Adam, Director,
Agricultural Promotion
Ministry of National Development

Dr. Richard T. Wurster
Chief-of-Party
USAID/SECID Contract

Mr. A. Young
Chief Crop Development Officer
Ministry of National Development

July 27, 1983

APPENDIX 2: Dr. Graydon Kingsland's End of Tour Report
Dr. Wayne Sitterly's End of Tour Report

MEMO

TO: DR. G.R. CRADDOCK

FROM: G. KINGSLAND

DATE: 12 MARCH, 1984

RE: Terminal Report of Plant Pathologist for USAID/SECID Food Crops Improvement Project with Government of Seychelles

Attached please find the terminal report for project pathologist covering the period July 13, 1981 through March 31, 1984.

cc: Dr. W. Sitterly
Dr. G. Von Tungeln
Dr. O.J. Dickerson

TERMINAL REPORT FOR PLANT PATHOLOGY

SEGMENT OF USAID/SECID FOOD CROPS

IMPROVEMENT CONTRACT WITH MINISTRY

NATIONAL DEVELOPMENT, REPUBLIC OF

SEYCHELLES

INTRODUCTION: The Plant Pathology program has been in continuous operation since the arrival on location of G. Kingsland on July 13, 1981. Four short periods of time a pathologist was absent from the project, but the major thrust of the program was continued even during these absences. Kingsland was away on sick leave for six weeks in November-December 1981, and on leave for 4 weeks in July-August 1982. Kingsland departed Seychelles December 22, 1982 and W. Sitterly arrived January 24, 1983. Dr. Sitterly returned to U.S on sick leave for 3 weeks in May of 1983 and departed Seychelles for U.S. on January 21, 1984. Kingsland arrived on February 2, 1984 and was present until the project was terminated.

The pathologists on the project have engaged in cooperative efforts with the horticulturist, soil scientist and entomologist during the course of the project.

This report will follow the outline of the original position description with expansion of the objective of this description taken from the headings in quarterly reports whenever appropriate.

A. Plant Pathology laboratory: A design for a modest plant pathology laboratory measuring 20' x 20' was submitted to Chief Research Officer in October of 1981. Release of a building near the Grand Anse Experimental and Food Production Centre by the U.S. Satellite Tracking Station facility to the Seychelles Government was accepted for the facility and this necessitated revision of the floor plans to accommodate construction in this building. Construction of the laboratory was completed except for fume hoods in July of 1983 and, in general, was constructed in conformity with the original design. A second level was added to the building at the new site, which accomodates the offices of the plant pathologist the soil scientists, and counterparts. The laboratory is highly functional and has ample storage and work space for plant pathology work. The main section contains a controlled environment chamber for culture work and media dispensing. The microscope work room is separated from the main section and from an adjacent office.

Diseased specimens brought into the laboratory are diagnosed by symptom recognition or are processed for pathogen identification by isolation into pure culture by standard procedures.

Photographic records can now be made of diseased specimens, since the project is supplied with a Minolta camera, flash unit, focusing rail, 135 mm lens for magnification and all necessary attachments.

B. The training and education of a Seychellois counterpart has been only partially successful. Mr. Antoine Young is a very capable and diligent individual. He was on location and very capably carried out the responsibilities of Pest Control Research Officer at time of arrival of the project pathologist and entomologist in July, 1981. Mr. Young was very helpful in organizing disease surveys and assisting the project entomologist with insect investigations during the first five months of the project. Mr. Young was subsequently given additonal administrative responsibilities and was away from Grand Anse Center for increasingly longer periods of time. The project pathologist contributed very little to Mr. Young's professional development subsequent to January 1982. I am, however, deeply appreciative of the fine cooperation and working relationship with Mr. Young during the early part of the project.

Mrs. Yacintha Pillay Johnson graduated from University of BWI and assummed the responsibilities of Agricultural Research Officer at Grand Anse in October, 1983. Yacintha and Dr. Sitterly worked together until Dr. Sitterly's departure January 21, 1984. Mrs. Johnson has learned many of the basic procedures of disease diagnosis, pathogen isolation and fundamentals of control recommendations. The elimination of the Seychelles Agricultural Extension will necessitate additional extension responsibilities for the Seychellois counterpart on the pathology segment of the project.

The Agricultural Officer at Grand Anse, in addition, should undertake some field plot work for pesticide development and for applied research or alternative methods of control.

Koch's rule of proof have been carried out for several of the pathogens identified since the project commenced in July 1981. Diseases with unknown etiology are abundant on the fruit and vegetable crops of the Seychelles. A certain amount of effort should be devoted to investigations of suspected pathogens of these disease problems. A considerable body of knowledge has been accummulated on the pathology segment of this project. Newspaper articles and extension-type publications have been written. Another important responsibility of the Agricultural Officer should be continued which relates to the expanded use of radio and T.V. broadcasts and for newspaper articles to disseminte plant pathology information in Seychelles for agriculture, food production and Seychellois welfare.

In view of the complexity and numbers of problems with plant diseases and pests in Seychelles, it is my opinion that it would be of advantage to provide opportunity for the Agricultural Officer in plant pests to attend a reputable and fully accredited University for work towards a M.S. degree.

C. Two "O" level technicians were assigned to the pathology-entomology unit of the project at the time the project was initiated in Seychelles (July, 1981). The research schedule was sufficiently occupied during the June-July 1982 period of activity of the entomologist to justify a third technician for this period. These technicians have worked in close cooperation with both plant pathologists and with the entomologist when present on a day to day basis during the entire project.

As a general rule, the work schedule developed around an early morning discussion of activities to be attended to during the day, or forthcoming days. Notes concerning procedures and projects frequently were written to communicate ideas.

The technicians worked very closely on a regular basis with the entomologist, Dr. M. Shepard, on a variety of problems involved with Mediteranian fruit fly trapping, population studies, rearing and control. They also received training under the entomologist on sprayer calibration and use safe use of pesticides. They were given instructions in identification of insects and diagnosis of insect injury to plants. Methods of biological control were discussed and parasites were introduced for studies on control of diamond back moth (Plutella sp). The technicians worked on all phases of this project.

Joint efforts were initiated with insect vectors of suspected virus diseases. The technicians learned insect trapping and rearing techniques, and were provided experience on transferring several species of insects from one host to the other under controlled conditions, i.e. screen and sleeve cage environments.

The technicians have worked on all phases of all projects with both pathologists and, in addition, have gained experience from working with the horticulturist and the soil scientists.

They have gained experience and training in many phases of field plot design, and implementation. They have been responsible for all phases of soil preparation, nursery operation for seedling production, transplanting, fertilization, cultural practices for growing plants, safe and proper use of pesticides,,and harvesting and summarizing results of field research data. They have received basic training in the principles and practices of diagnosis of plant diseases of all types. Field plot work also has included supervision of laborers, methods of diagnosis and rating of disease, and special techniques such as replication and randomization. The many problems studied during the course of the project also has necessitated

work with soil treatments and methods of evaluation of effect on both pathogens and hosts.

They also have received training and education in the most important aspects of laboratory operations such as media preparation, isolation techniques, pure culture work, use of microscopes and attachments such as micrometers, spore counting and culture preservation. They also have had experience in inoculation of host plants with a wide variety of pathogens such as bacteria, fungi and viruses. Short discussions of the reasons, and explanations of the various procedures, have been conducted during all operations to further provide an educational base for these technicians.

The technicians have been given considerable responsibility in conducting the day to day operation of field fungicide and nematicide experiments. Daily conferences were employed to coordinate activities. The are able to anticipate and solve several types of problems involved with cultural practices and field plot operations.

Mr. R. Hoareau attended a special three month course in plant pathological and entomological methods at Clemson University during 1982.

D. A new screenhouse has been constructed.

Twelve 3' x 3' x 3' screen cages also are available for growing plants in an insect-free environment. These cages can be employed for screening plants in field plots. Several experiments with caging of insects on tomato plants for studies of tomato jaune disease were conducted with these cages.

These cages also were used for growing plants which had been mechanically inoculated with homogenate from plants with virus diseases or with symptoms resembling virus diseases.

E. Surveys for diseases and insects of fruit and vegetable crops in the Seychelles were commenced during the first two weeks of the Project. Visits were made to farms in various sections of both Mahe and Praslin.

Dr. Shepard, project entomologist, determined that Mediterranean fruit fly on passion fruit and diamond back moth on cabbages were two of the major insect problems on the islands as a result of these surveys. He was able to tabulate information which corroborated opinions of Mr. C. Adams (CRC) and Mr. Young (PCRO). Much of Dr. Shepard's program developed around the information obtained on these surveys.

The early disease surveys indicated that root-knot nematode, tomato jaune disease, cabbage black rot, an unknown leaf spot of tomatoes, bacterial wilt of solanaceous crops, anthracnose of papayas and guavas, and nutrient deficiency diseases were major problems confronting Seychelles agriculture. These surveys were conducted on a continuing basis throughout the entire course of the project. Farm visits were conducted on an almost weekly basis to diagnose disease problems and recommend control measures. Extension service personnel and a peace crop volunteer frequently brought specimens to the laboratory, or requested assistance in the field to review on-farm problems. This source of information and problems contributed to the accumulated data now available relating to disease and insect problems in the Seychelles. The loss of the peace corp volunteer in March 1982, the closing of extension offices on the island, and reduced contacts with Mr. Young (PCRO) seriously impeded progress of on farm contacts. Additional time, consequently, was required for the pathologist to drive at random in search of farmers who might have problems. Mrs. Johnson and the current project pathologist spend one half day per week visiting one to three farmers in various sections of Mahe. This procedure is inefficient at best

The results of information from these surveys have been summarized in quarterly reports, published in news items for the Nation or articles written for the CRO, published as a scientific contribution to Tropical Pest Management, and in a publication entitled "Diseases and Insets of Fruit and Vegetable Crops in the Republic of Seychelles". This later manuscript should be published by late April to mid-May 1984.

F. Several diseases were identified early in the project that were of sufficient importance to justify field and/or laboratory investigations. Root-knot nematode was found to be serious on tomatoes, cucumbers, okra and papaya. Two experiments with nematicides were carried out on tomatoes at Port Glaud in a field with high populations of nematodes. A complete cost analyses was performed on one of these experiments. In general, Nemacur, was the most effective material used. Several experiments were conducted with plastic mulch over the plant beds as a potential control for nematodes. This method is considered not to be feasible at this time. A comprehensive survey for nematodes on fruit crops was conducted. The highest populations of nematodes occurred on papayas. However, papaya were more intenisvely sampled. Radopholus similis, burrowing nematode, was found to be a problem on bananas on many farms. A leaf spot disease of tomatoes of unknown etiology was proved to be caused by Corynespora cassiicola, which is the first report of this pathogen from Seychelles. This disease is the most important leaf lesion disease of tomatoes in Seychelles. A series of fungicide trials were carried out with this disease which indicated that Bravo and Difolatan were the most effective fungicides to give control, a spray timing schedule for control of this disease was worked out by Dr. Sitterly and reported by

him at the ISHS Symposium in July, 1983. A disease of unknown etiology on tomatoes is expressed by interveinal chlorosis, epinasty, stunting, poor fruit set and incomplete lateral shoot formation. This syndrome is referred to as tomato jaune disease, since it resembles a disease with this name found in Ivory Coast. Inoculation studies, ability to transmit with insects and seed transmission studies for this disease have produced negative results. Economic losses from several experiments have been determined and were reported at the ISHS Symposium in July 1983. Experiments currently are in progress with this disease at GAC. A very thorough study of harvesting, handling, transport and storage problems of tomatoes was conducted during 1983. Major problems and origin of farm to market losses were documented. Recommendations for improving practices in all segments of the farm to market of produce were incorporated into the final report. Sclerotium stem blight was diagnosed on pole beans at Farmers Training Center. Economic losses from this disease were estimated and reported at ISHS in July, 1983. Control by soil fumigation was initiated, but was not carried out.

Losses of 10%, 60%, 100% and 22% were recorded, respectively, for Fusarium sp. on watermelon, bacterial wilt of two plantings of eggplant and bacterial soft rot of tomatoes.

Research was conducted on sanitation and fungicides for control of Cercospora leaf spot of green peppers. This research will be discussed under section G.

Koch's postulates were conducted for suspected pathogenns of cane blight of passion fruit, colletotrichum on pepper, colletotrichum on mango, tomato jaune disease, Corynespora leaf spot of tomatoes, Fusarium root rot of papaya, Alternaria leaf spot of Acalypha indica, suspected viruses in Epi Bleu and Beach bean (as wild hosts which might harbor viruses of cultivated plants) and Colletotrichum on papaya fruit.

Infection (symptom) characteristics were defined for powdery mildew of papaya and Cercospora leaf spot of l'herb coco.

G. The basis for an integrated program in plant disease control has been established for Seychelles by the project. All recommendations for disease control to growers have included statements on the use of sanitation, rotation and other methods of control which provide satisfactory alternatives to fungicides. The illustrated handbook "Diseases and Insects of Fruit and Vegetable crops in Republic of Seychelles" includes recommendations for all feasible methods of control for diseases. Recommendations and reports written on this project, and talks given to extension personnel, have emphasized the importance of safe use of pesticides; using the minimum quantity for obtaining the desired control result; care in dispensing, labeling and storing of pesticides; and prevention of environmental contamination by pesticides.

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Research was completed during 1983 on minimum use of fungicides for control of Cercospora leaf spot of peppers by utilizing sanitation as an additional measure.

Experiments with Corynespora leaf spot of tomatoes emphasized reduction in amount of fungicides by increasing time intervals between sprays when possible.

The plant pest regulations and quarantine act of 1925, and the 1958 amendment, was reviewed and several changes recommended in 1983. Plant materials brought into the Seychelles were examined for pathogens on several occassions. Destruction of one shipment was recommended, since many pathogens were identified and the plant materials introduced were not known to possess horticultural characteristics superior to varieties in use.

The project entomologist utilized populations of Med. fruit flies as a basis for prediction of insecticide applications. Parasites of diamond back moth on cabbage were introduced as a potential means of biological control.

H. Disease ratings have been recorded on the major diseases encountered on most vegetables during disease surveys and in the process of diagnosing problems delivered to the GAC. Entries in the variety trials conducted by the horticulturist and by GAC have been rated for disease incidence and intensity. The results of these writings are recorded in all quarterly reports.

Ratings of the cassava varieties entered in the trials at GAC were rated for African cassava mosaic. The details of these ratings, and a discussion of the etiology of ACM and alternative rating systems, is included in the Quarterly Progress Report for January 1 through March 31, 1982.

I. Field research has been conducted year-around during all years of the project. Trimming of diseased leaves to eliminate sources of inoculum have been routinely carried out and has been a part of control recommendations for many diseases. No research specifically designed for dates of planting or rogueing has been conducted.

J. Activities under plant quarantine have been discussed in section G.

-L. The training for Seychellois counterparts and techicians was discussed in sections B and C. An overseas training program for the second technician was not approved by Government of Seychelles.

M. The most important texts and references (list attached) are now on location. Two reference manuals for specific pathogens (bacteria and nematodes) are on order.

N. Three lectures were presented to extension workers, plant quarantine workers and FTC students during the second year of the contract (1982). Additional lectures were presented to these groups and, in addition, to students at Polytechnical school during 1983.

O. Several field days were conducted for farmers and for extension personnel during each year of the project. Basic principles of symptom recognition and disease control were presented. A booth with numerous demonstrations was set up in cooperation with Mr. Young for FAO year of agriculture and for independence day 1982 celebrations.

The project pathologist devoted a significant proportion of his time in preparation for the ISHS symposium held in Seychelles in July, 1983.

P. Short articles on general plant pathology or covering specific diseases have been written for the "Nation", the Seychelles national newspaper, at regular intervals. Reports of the results of the diagnosis of plant diseases, including recommendations for control, were written for return to growers for all diagnosis. This entire process now has been taken over by Mrs. Johnson.

An 80 page (approximate), illustrated publication entitled "Diseases and insects of fruit and vegetable crops in the Republic of Seychelles" is schedule for 1,000 copy release in late-April to mid-May. The articles in this publication have been used as the basis for a series of radio programs on plant pest problems in the Seychelles. They are currently being translated into Creole by Mr. Paul Denousse for use over radio and in news articles and for possible incorporation into the illustrated publication.

Q. Training of extension personnel occurred as a result of on-farm visits with the pathologist during 1981 and 1982. Principles of plant pathology, disease diagnosis, epidemiology and control were discussed and illustrated during these sessions. Weekly conferences were held at GAC with extension officers. Disease problems were discussed informally, but no organized series of lectures were presented. Extension was de-emphasized during 1983 and, although, training was continued for as long as possible, the role of the pathologist as educator in extension necessarily diminished.

R. Four papers on project research in plant pathology were presented at ISHS. A paper has been published in Tropical Pest Management on Diseases of Seychelles. Another paper for TPM is being written on chemical control of corynespora leaf spot. A paper has been submitted to Plant Disease on a newly-discovered leaf spot disease of Acalypha indica and a second paper for PD is being reviewed on pathology of corynespora leaf spot. The illustrated book is due for publication in late April to mid-May.

Numerous special reports have been written for Seychelles Chief Research Officer and for AID/SECID Chief of Party throughout the project.

S. Both project pathologists have visited Praslin on disease problems. Problems sent from all islands away from Mahe have been processed during the contract.

T. Addenda. Contributions beyond the stated project objectives have resulted from the activities on this project. Many of these have scientific, as well as pragmatic, value.

Cultures of at least 34 fungi from Seychelles were sent to, and deposited in, the world-wide culture collection at Commonwealth Mycological Institute, Kew, Surrey, U.K. The assistance of mycologists at CMI has been invaluable of this project. The cultures sent constitute important additons to the CMI collection, since these are among the first to be entered from Seychelles.

The entry of many of the diseases of the Seychelles into the world scientific literature constitutes the first publication record of most of these diseases. Some are reports of new disease records from Seychelles.

Modifications and improvements in many stages of vegetable seedling production in the nursery have been made by Dr. Sitterly. These improvements are of importance to the rapid production of seedlings and other plant propagating units to GAC and to the Seychelles public.

U. Retrospect

1. A consignment of equipment was present on location when the pathologist arrived in July 1981. Many items of this equipment were of little or no use to the project. Other items were wired for 110V current rather than 220V, which is the current supplied by Seychelles Electricity Corporation.

   The arrival of some research instruments, equipment and supplies prior to the appearance of project personnel is advisable whenever need, utility and and service ability is assured.

   It is important, however, to be assured that all three criteria are satisfied before ordering these materials.

2. A truck was purchased with project funds prior to arrival of project participants. The truck was in use prior to arrival of project participants and difficulty of retrieval resulted in the diversion of truck to other individuals and loss of use to project participants. Vehicles should be purchased to arrive after or at time of project participants. Specific use statements should be clearly defined and understood.

V. Quarterly reports were not reviewed in detail in composing this report. Consequently, certain sections may not have been treated in appropriate detail. Certain aspects of Dr. Sitterly's work may not have received

the attention that it merits, although the author of this report has attempted to cover all phases of the project since its initiation.

Contributions from the entomology segment have been entered in this report wherever deemed appropriate. These references constitute only a small portion of the entomologist's contribution.

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Note: Kranz, Schmutterer and Koch 1977. Diseases, Pests and Weeds of Tropical Crops, was sent to Seychelles prior to October 5, 1983, but is not on location at Grand Anse.

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# Plant Diseases in the Republic of Seychelles

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*Clemson University, Clemson, South Carolina 29631, USA.*

**Abstract.** Fiftyfive plant diseases of 31 species of cultivated and uncultivated hosts are reported for the Republic of Seychelles. Brief descriptions of the climate and agriculture of the Seychelles are presented, together with a discussion of the relationships between these factors and plant diseases. The main islands of the Seychelles are separated from East Africa, the closest contiguous land mass, by about 1600 km. All food crops have been introduced to the islands from other areas, especially Mauritius. The pathogens responsible for most of the diseases reported provide examples of inadvertent, long-range transport by man.

## Introduction

The economic and political activities of the Republic of Seychelles are centred on the granitic islands of Mahe, Praslin and La Digue. These islands, together with about 40 smaller islands, constitute the northern-most end of the Seychelles – Mauritius ridge, and are located at 4°S latitude and 46°E longitude in the Indian Ocean. The Seychelles islands are separated by about 1600 km of ocean from East Africa, the closest contiguous land mass, and lie about 965 km NNE of Madagascar.

The Seychelles occupy a total land area of 44,427 ha, 22,100 ha of which are arable. Nearly all of the food crops are grown on Mahe, Praslin and La Digue which together have a land area of 21,307 ha. The remaining 23,120 ha is occupied by 60 widely scattered, low-relief, coral-sand islands. The amount of arable land of the central islands is estimated to be about 810 ha. Total land holdings of large and small farmers in Seychelles is about 10,500 ha, 650 ha of which is estimated to be under cultivation for fruit, vegetable and root crop production (Anon., 1980).

Proximity to the Equator, a small land area (Mahe, the largest island, is 14,606 ha), an oceanic environment and annual wind patterns give the Seychelles a tropical marine climate. Annual precipitation averages 240 cm with a variation of 171.8–303.9 cm at different locations (five-year averages at 21 locations), with most rainfall occurring during the northwest monsoon (trade) season from October to April (Table 1). The southeast monsoon (trade) occurs from May to September. Monthly precipitation may vary from 2.1 to 57.4 cm at different locations. Mild temperatures with very small (1–2°) deviations above and below the monthly means of 27.7° (five-year average day temperature from one sea level location) characterise the temperature pattern of the Seychelles (Table 1). Extremes of average monthly temperature vary between a low of 24.5° (five-year annual average of 25.5°) to a high of 31.8° (five-year annual average of 30.7°).

Plant diseases cause production problems throughout the year. They appear to be more serious during the northwest monsoon than during the southeast monsoon, because of the higher amount of rainfall occurring on more days during the northwest monsoon. Serious crop losses during the northwest monsoon also occur as a result of flooding. Losses of S.R. 1,000,000 (US $161,300), for example were recorded on 13 November 1981 on Mahe as a result of flooding by 25.8 cm of rain in one 12-h period (Anon., 1981). Conversely, regular irrigation from supplies which are frequently limited is necessary during the southeast monsoon from May to September.

The only food plants native to the Seychelles are the coconut palm (*Cocos nucifera* L.) and the palmiste palm (*Deckenia nobilis* H. Wendl.), the shredded terminal meristem of which is used in palmiste salad. The introduction of plants of economic importance occurred with the original colonisation of the Seychelles by settlers from Mauritius in 1770 (Fauvel, 1909). The earliest introductions included coffee, cotton, tobacco, rice, sweet

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TABLE 1. MONTHLY AND ANNUAL PRECIPITATION (cm) AND TEMPERATURE (°C) AVERAGES IN THE SEYCHELLES

| Month | Precipitation | Temperature | Month | Precipitation | Temperature |
|---|---|---|---|---|---|
| January | 37.7 | 27.7 | July | 9.3 | 26.7 |
| February | 31.3 | 28.7 | August | 8.5 | 25.4 |
| March | 19.0 | 28.2 | September | 7.5 | 27.8 |
| April | 24.7 | 28.5 | October | 21.0 | 27.7 |
| May | 13.5 | 28.2 | November | 22.1 | 27.7 |
| June | 8.2 | 27.0 | December | 37.4 | 27.7 |
| Monthly average | – | – | – | 20.0 | 27.7 |

potatoes, maize, cassava, fruit trees, bananas, sugarcane, clove, nutmeg, pepper, cinnamon, pineapples and vegetables. Propagative materials were brought to Seychelles under the authority of the colonial administration in Mauritius and also, without doubt, by individuals transporting their own materials.

A second period of plant introductions began in 1903, with propagating materials entering the Seychelles from world-wide sources under the direction of DuPont (DuPont, 1903). The peak year of this activity was 1911 when 268 species of plants were introduced from such diverse sources as USA, Antigua, India, Mauritius and other countries (DuPont, 1911). Insect pests were referred to in 1907 (DuPont, 1907), but no reference to specific diseases appeared during the early 1920s.

A third period of introductions was initiated by B. Smith in 1965 (C. S. Adam, personnal communication) in a more selective manner with seeds originating from reputable seed firms in France, USA, Japan, India, Mauritius, South Africa, UK, China and Taiwan. Disease-free meristem cultures of sweet potatoes (*Ipomoea batatas* (L). Poir.) and cassava (*Manihot esculenta* Crantz) are brought into the islands under permit from the International Institute of Tropical Agriculture, Ibadan, Nigeria.

Jeffrey's (1963) descriptions of 11 genera of Cucurbitaceae in the Seychelles further illustrates the importance of introduced economic plants. None of the genera are native, but have been introduced from various tropical areas around the world.

Restrictions on the importation of plant propagating materials into Seychelles did not appear until the enactment of the Plant Pests Ordinance of 1925 (Anon., 1925). A 1958 amendment to the Ordinance required that introduced plants, plant parts, or products be accompanied by a phytosanitary or plant inspection certificate from authorities in the country of origin certifying that materials have been inspected and found to be disease and pest free. Special conditions, such as fungicide treatments, also may be specified. Plant materials from regions with known serious diseases or insects, not present in Seychelles, are ineligible for introduction. In addition, plants or plant parts shall not be rooted or packed in earth, leaf or garden mould, compost or farmyard manure, or packed in straw or unsterilised sphagnum moss. Entry of most of the plant pathogens present in Seychelles today probably occurred during the 155 years between the first plant introductions (1770) and the appearance of the first legislature for control of plant diseases in 1925.

At present agriculture on the central islands of the Seychelles is a mix of plantation agriculture, small farms operated by independent producers or by 'blockers' who operate small farm plots of state-owned land, and farms owned and operated by the state (Seychelles Agricultural Development Corporation—SADECO).

The remnants of plantation agriculture in the Seychelles is represented by 70 farms (plantations) classified as large, occupying 9200 ha of land with an average of 131 ha unit. Only 210 ha (3.0 ha/unit) of this land is cultivated for fruit and vegetable production. The remainder is devoted largely to coconuts. The coconut is the plantation crop with the longest history; it occupies the largest area (6520 ha) of land on all of the islands (several of the outer, coral-sand islands are devoted almost exclusively to coconuts), and is the crop of major economic importance, accounting for 3136 t of export copra in 1981.

Cinnamon (*Cinnamomum zeylanium* Nees.), introduced from Mauritius during the early colonial period, was not originally successful as a spice crop. Introduced plants escaped from cultivation. Cinnamon currently constitutes a major component of the non-cultivated vegetation at all elevations throughout Mahe. Stripping of the bark

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from these wild trees supplied 230 t of dried bark for export in 1981. An additional 189 t was supplied by bark from large farms.

Tea (*Camellia sinensis* (L.) Kuntze) was introduced from Kenya, Tanzania and Uganda as seed from cultivars originally from India in 1963. It is currently grown on 52.6 ha of steep, mountain terrain in four production units on the west-central portion of Mahe. Production by SADECO amounts to about 40,000 kg/year (fresh weight) which is processed almost exclusively for local consumption by the Seychelles Tea and Coffee Company Ltd.

Five state farms operated by SADECO have 58 ha under cultivation for fruits, vegetables and root crops. Approximately 73% of the fresh fruit and vegetables for consumption on the central islands is produced on 634 small farms occupying a land area of about 430 ha. Breadfruit (*Artocarpus communis* Forst.), cassava, cocoyams (*Colocasia esculenta*) (L.) Schott), sweet potatoes and yams (*Dioscorea alata* L.) also are produced on these farms as a supplement to imported rice (8000 t in 1981). The small farms vary from 0.1 to 6.1 ha in size and average 0.8 ha. The total includes 200 blockers who farm rented plots of state-owned land. Approximately 85 to 90% of the disease problems referred to in this paper originated on small farms. Disease problems also were studied on crops at the National Youth Service school at Port Launay, at two of the SADECO farms, and at the French Pilot Farm at Anse a La Mouche.

Previous records of diseases of the Seychelles are contained in a paper by Mathias (1971), and in reports of a one-week survey by Bock (1976) and a three-week survey by Kaiser (1977). Mathias referred to citrus canker, bacterial wilt of tomatoes and other crops, bacterial leaf spot of tomatoes and bacterial root gall of several hosts. He listed 15 species of fungal pathogens on vanilla, tomatoes, beans, tobacco, cassava, pawpaw, sugarcane, bananas, tea and sorghum. *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949 and *M. incognita* (Kofoid & White, 1919) Chitwood, 1949 were reported as responsible for severe damage to tomato, tobacco, eggplant, patchouli, carrots and red beets. Bock's report dealt almost exclusively with virus diseases. Kaiser's report dealt primarily with viral and bacterial diseases. The results of the studies reported in this paper are an addition to the knowledge of the range and distribution of plant pathogens, provide information concerning long-range dissemination of pathogens by man and contribute much-needed information concerning phytopathological aspects of the agriculture of the Seychelles.

## Methods

The information presented here was gathered from surveys of plant diseases on Mahe and Praslin, or it was obtained from specimens delivered to the plant pathology laboratory at Grand Anse Center. Fungus pathogens were identified by observation of microscope mounts of fungus structures transferred directly from diseased tissue, or by isolation of pathogens into pure culture from diseased tissue onto cornmeal agar (17 g Difco Cornmeal agar/*l*) and/or potato-dextrose agar (39 g BBL potato-dextrose agar/*l*) for identification *in vitro*. The identity of several pathogens was determined from cultures and/or from diseased host speciments by mycologists at the Commonwealth Mycological Institute (CMI), Kew, UK.

Nematodes are referred to by genus on the basis of symptoms, and, for root-knot nematodes, from eggs and diseased root specimens sent under permit to the International Meloidogyne Project* and to Clemson University†.

The pathogens responsible for viral and bacterial diseases are listed only for those diseases for which etiological agents are well-known and widely recognised.

Miller *et al.* (1960) was employed as the principal source of host taxonomy and nomenclature. Miller *et al.* (1960) and results of identifications from CMI were the sources employed for nomenclature and authorities for pathogens.

## Results

Table 2 is a summary of the plant diseases identified to date in the Seychelles. The host and pathogen are also listed, together with notes on occurrence, distribution, economic importance, symptom expression or identification. None of the pathogens observed are considered to be indigenous to, or unique to, the Seychelles, but are known to occur in other areas of the world. Consequently, it is believed that most of these pathogens have been introduced to the Seychelles by man in his migrations to the islands.

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TABLE 2. PLANT DISEASES, HOSTS AND PATHOGENS IDENTIFIED IN THE SEYCHELLES

| Host | Disease | Pathogen |
|---|---|---|
| Anacardiaceae | | |
| *Anacardium occidentale* L. (cashew) | Anthracnose | *Colletotrichum* sp. |
| Sunken, 4 to 10 mm, brown to black fruit lesions with abundant yellow-orange acervuli. | | |
| *Mangifera indica* L. (mango) | Leaf spot | *Phomopsis mangiferae* Ahmad |
| *P. mangiferae* was isolated from leaf lesions on Benganpalli mango at Grand Anse Center, Mahe. | | |
| *M. indica* | Anthracnose | *Colletotrichum* sp. |
| Anthracnose has been identified on pedicles of the inflorescence of mango from several locations on Mahe. The pathogen is responsible for premature flower abscission, inflorescence blight and poor fruit set. | | |
| Apocynaceae | | |
| *Plumeria* sp. (frangipani) | Crown gall | Unknown |
| Enlarged, rugose galls typical of crown gall were observed on branches of frangipani at Turtle Bay, Anse Aux Pins. | | |
| Caricaceae | | |
| *Carica papaya* L. (pawpaw) | Powdery mildew | *Ovulariopsis papayae* van der Bijl |
| Powdery mildew is a common disease of the middle and lower leaves of pawpaw, characterised by chlorotic leaf lesions averaging 6.0 mm in diameter. Mycelium on lower leaf surface produces conidiophores with a single obovate to slightly clavate conidium typical of *O. papayae*. This pathogen is not listed in the host index (Miller *et al.* 1960) and is the first report of this disease in the Seychelles. | | |
| *C. papaya* | Anthracnose | *Colletotrichum capsici* (Syd.) Butler and Bisby |
| This disease occurs frequently on mature fruit. | | |
| *C. papaya* | Cercospora leaf spot | *Cercospora* sp. |
| Identified from one location on Mahe on local, necrotic leaf lesions. | | |
| *C. papaya* | Mosaic | Unknown |
| Identified on one plant in a field of 28 on Mahe. Leaf deformation as strap leaf of lobes occurred together with the typical mosaic symptom. | | |
| *C. papaya* | Root knot | *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949 |
| The disease occurs throughout Mahe and Praslin. The pathogen was identified from root samples from Praslin. | | |
| Compositae | | |
| *Lactuca sativa* L. (lettuce) | Cercospora leaf spot | *Cercospora* sp. |
| Convolvulaceae | | |
| *Ipomoea pes-caprae* (beach morning glory) | Cercospora leaf spot | *Cercospora ipomoea* Wint. |
| Beach morning glory is widely distributed in the tropics, and is aboriginal in the Seychelles, where it is confined to the beach environment. *Cercospora ipomoea* has been reported on this host from Texas and Puerto Rico (Miller *et al.*, 1960). | | |
| Cruciferae | | |
| *Brassica oleracea* L. (cabbage) | Black rot | *Xanthomonas campestris* (Pam.) Dows. |
| *Brassica pekinensii* (Lour.) Rupr. (Chinese cabbage) | White rust (Kaiser, 1977) | *Albugo candida* (Pers. ex. Chev.) Kuntze |
| Cucurbitaceae | | |
| *Citrullus vulgaris* Schrad. (watermelon) | Watermelon mosaic | Watermelon mosaic virus |
| This is the disease which has been observed most frequently on cucurbits in Seychelles. Leaf sample preparations of several species of the Cucurbitaceae revealed 750 nm long, filamentous particles when observed by electron microscopy (Bock, 1976). | | |
| *Cucumis melo* L. (muskmelon) | Watermelon mosaic | Watermelon mosaic virus |
| *Cucumis sativus* L. (cucumber) | Corynespora leaf spot | *Corynespora cassiicola* (Berk. & Curt.) Wei |
| This disease is characterised by angular, light brown, 6—8 mm wide, necrotic lesions. *Corynespora cassiicola* is the only fungus associated with a high percentage of these lesions. Pathogenicity of this fungus on cucumber has been demonstrated (Kingsland, 1982). | | |
| *C. sativus* | Powdery mildew | *Oidium* sp. |
| *C. sativus* | Root-knot | *Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949 |
| Responsible for loss of entire crop in one farm on Praslin. Present on both Mahe and Praslin. Species identified from Praslin. | | |
| *C. sativus* | Watermelon mosaic | Watermelon mosaic virus |
| *Cucurbita maxima* Duch. (winter squash or pumpkin) | Watermelon mosaic | Watermelon mosaic virus |
| *Momordica charantia* L. (bittergourd) | Watermelon mosaic | Watermelon mosaic virus |
| *Tricosanthes anguina* L. (snakegourd) | Watermelon mosaic | Watermelon mosaic virus |
| *Lagenaria siceraria* (calabash) | Watermelon mosaic | Watermelon mosaic virus |

TABLE 2—continued

| Host | Disease | Pathogen |
|---|---|---|
| Euphorbiaceae | | |
| *Acalypha indica* L. (herbe chatte) | Alternaria leaf spot | *Alternaria* sp. |
| *Acalypha indica* is a low-growing, herbaceous, plant which invades garden and farm plots, and field margins, and rapidly becomes a major component of the non-cultivated herbaceous vegetation, especially on the coral-sand and plateaux soils of the central Seychelles. No previous reports of this disease have been found. | | |
| *Manihot esculenta* Crantz. (cassava) | Brown leaf spot | *Cercospora henningsii* Alleseh |
| Distributed throughout in moderate to high incidence. Responsible for premature defoliation. Appears not to result in losses of economic importance. | | |
| *M. esculenta* | Cassava mosaic | Unknown |
| Present in all plots of unimproved varieties surveyed. Improved varieties from meristem tip cultures from international sources are available. | | |
| Graminiaceae L. | | |
| *Zea mays* L. (sweet corn) | Leaf rust | *Puccinia* sp. |
| Identified at SADECO farm (Anse Aux Pins) on 2% of plants of an unidentified sweet corn variety. | | |
| *Z. mays* | Mosaic | Virus |
| Symptoms resembling sugarcane mosaic virus were present on 15% of plants at SADECO's Anse Aux Pins farm. Sugarcane with virus symptoms was present in an adjacent field. | | |
| *Stenotaphrum complanatum* (herbe coco) | Cercospora leaf spot | *Cercospora fusimaculans* Atk |
| Lauraceae | | |
| *Cinnamomum zeylanicum* Nees. (cinnamon) | Sooty mold | Unknown |
| Sooty mold occurs at all locations on cinnamon throughout Mahe. | | |
| Leguminosae | | |
| *Phaseolus vulgaris* L. (bean) | Leaf blight | *Xanthomonas phaseoli* (E. F. Sm.) Dows. |
| *P. vulgaris* | Leaf rust | *Uromyces phaseoli* (Pers.) Wint. |
| *P. vulgaris* | Cercospora leaf spot | *Cercospora canescens* Ell. & Mart. |
| *P. vulgaris* | Sclerotium stem blight | *Sclerotium rolfsii* Sacc. |
| Sclerotium stem blight has been identified from one location in Mahe, and was responsible for 12% crop loss. Tomatoes and cucumbers grown on this location following beans did not show symptoms. | | |
| *Vigna marina* (beach bean) | Mosaic | Unknown |
| *V. marina* is a commonly occurring trifoliate vine confined to the littoral beach thicket plant community of various beaches of Seychelles. A mosaic symptom, accompanied by local rugose areas of some leaves, frequently is present on this species. Transmission by leaf-rub of homogenates from diseased plants to several indicator species has been unsuccessful. | | |
| Malvaceae | | |
| *Hibiscus esculentus* L. (okra) | Root-knot | *Meloidogyne* sp. |
| Responsible for 100% loss of 25 plants in one plot at Anse Boileau. Root-knot also was identified on 100% of mature plants, causing extremely severe galling, at Farmers Training Center at Anse Boileau. This disease may be a limiting factor for okra production unless control measures are carried out. | | |
| Musaceae | | |
| *Musa* spp. (banana) | Burrowing nematode | *Radopholus similis* (Cobb, 1893) Thorne, 1949 |
| Palmaceae | | |
| *Cocos nucifera* L. (coconut) | Gray leaf spot | *Pestalotia phoenicis* Vize. |
| This disease is common in all areas of the Seychelles. It does not appear on leaves 1 to 5, but is generally present on all of the older leaves of coconut palms. | | |
| Passifloraceae | | |
| *Passiflora laurifolia* L. (passion fruit) | Anthracnose — cane blight | *Colletotrichum* sp. |
| Sixty-five percent of the canes on three trellises of passion fruit on Praslin manifested severe cane blight symptoms. *Colletotrichum* sp. and *Botryodiplodia theobromae* Pat. were isolated from these plants and from plants with cane blight from La Digue. | | |
| Rutaceae | | |
| *Citrus sinensis* Osbeck (orange) | Leaf scab | *Elsinoe fawcetti* Bitan. & Jenkins |
| Solanaceae | | |
| *Capsicum annuum* v. *grossum* (green pepper) | Anthracnose | *Colletotrichum capsici* (Syd.) Butler & Bisby |
| *C. annuum* v. *grossum* | Bacterial leaf spot | *Xanthomonas vesicatoria* (Doidge) Dows. |
| *C. annum* v. *grossum* and *V. longum* (chilli pepper) | Mosaic | Virus |
| This is the most commonly occurring disease of both bell and chilli peppers. Cucumber mosaic virus is the suspected causal agent (Bock, 1976; Kaiser, 1977). | | |

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TABLE 2—continued

| Host | Disease | Pathogen |
|---|---|---|
| *Lycopersicon esculentum* Mill. (tomato) | Corynespora leaf spot | *Corynespora cassiicola* (Berk. & M. A. Curtis) Wei. |
| *L. esculentum* | Leaf mold | *Cladosporium fulvum* Cke |
| *L. esculentum* | Early blight | *Alternaria solani* (Ell. & G. Martin) Sor. |
| *L. esculentum* | Bacterial wilt | *Pseudomonas solanacearum* E. F. Sm. |
| Identified as race 1 by A. Ramos, National Agricultural Laboratory, Nairobi, Kenya (Kaiser, 1977) | | |
| *L. esculentum* | Root-knot | *Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949. |
| A major threat to tomato production on coral-sand soils throughout Mahe and Praslin. Species identified from Mahe. | | |
| *L. esculentum* | Tomato jaune | Unknown |
| Symptoms of this disease are similar to 'la maladie jaune' described in Ivory Coast (Walter, B. *et al.*, 1980). Severe interveinal chlorosis, epinasty and dwarfing of the leaves are the most characteristic symptoms. Infection during the first month of juvenile plant development after transplanting results in stunting, absence of lateral shoots and diminished fruit set. Fruits which do set do not mature. Mechanical transmission with homogenates from infected plants, insect transmission with whiteflies (*Bemisia* sp.) and with seeds from diseased plants have not been successful (Kingsland, 1981). This disease was responsible for a yield loss of no less than 15% in one field of 1000 plants. | | |
| *L. esculentum* | Root rot | *Fusarium solani* (Mart.) Sacc. |
| Identified from one field on Praslin. | | |
| *L. esculentum* | Fusarium wilt | *Fusarium oxysporum* Schlecht f. sp. *lycopersici* Sacc. |
| Fusarium wilt has been identified from tomatoes on coral-sand soil at Port Glaud, Mahe. This disease was responsible for loss of 12% of the plants in one field. | | |
| *Solanum melongena* L. (eggplant) | Paracercospora leaf spot | *Paracercospora egenula* (Syd.) Deighton |
| *S. melongena* | Bacterial wilt | *Pseudomonas solanacearum* E. F. Sm. |
| *S. melongena* | Root-knot | *Meloidogyne incognita* (Kofoid & White, 1919) Chitwood, 1949. |
| Species identified from Praslin. | | |
| Verbenaceae | | |
| *Stachytarpheta indica* (epi bleu) | Mosaic | Unknown |
| *S. indica* is a common, suffruticose herb of roadsides, field margins and uncultivated areas in Seychelles. A mosaic symptom, accompanied by leaf dwarfing and deformity, is frequently seen on this species. Attempts to transmit a causal agent to healthy plants by leaf rub technique with homogenates from diseased plants have been unsuccessful. | | |

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EXIT REPORT OF THE CONTRACT PLANT PATHOLOGIST

USAID/SECID - SEYCHELLES FOOD CROPS RESEARCH CENTER

CONTRACT AFR-001-C-00-1032-00

JAN. 21, 1983 - JAN. 21, 1984

Wayne R. Sitterly

A) Disease and Pathogen Identification

A total of 69 plant diseases and their causal agents were diagnosed from the farms of producers, and recommendations were made for their control. Hosts included vegetables, fruits (including coconuts), and ornamentals (including orchids and antirrhinums). Causal agents were fungal, bacterial, viral, nutrient, and weather-induced in origin.

The Soils and Plant Diagnostic Laboratory was officially opened in December of 1984, at which time many more diagnoses were made and recorded in laboratory files.

A logging and traffic control system was developed for the diagnostic laboratory. This system may also act as a survey tool to be used in developing research needs and identifying practical problems. A copy of the information card sent to specimen owners is attached.

B) Disease Surveys

A tree fruit survey of guava, avocado, mango, lime, orange, papaya and star fruit showed that only papaya had nematode problems. Papaya were 40-80% infected with rootknot nematode, but showed a high degree of tolerance. Appropriate control procedures were recommended.

A survey and evaluation of transit and storage losses of vegetable produce from the outer islands to the grocery shelf in Victoria was conducted. Losses averaged 60%. An implementation plan to reduce this to a more acceptable 10% was submitted to the Ministry of National Development and was well-received by President Rene of Seychelles.

C) Determination of Losses From Plant Diseases

Throughout the year, losses from specific plant diseases were determined. This provides information for establishing research objectives as well as emphasizing the role of plant pathology in food production. Selected diseases and percent of loss are listed: watermelon *Fusarium* root rot (10%), rotting of tomato stems by compaction of wet coconut husk mulch (22%), bacterial wilt of eggplant (25-100%), tomato jaune virus (59-100%), tomato early blight (25%), cabbage boron toxicity (80%).

## D) Development of Programs for Control of Plant Diseases

### 1) Determination of Resistant Varieties

Throughout the year observations were made to determine what vegetable and fruit varieties were resistant to specific plant diseases. Many items require further confirmation evaluation, but the following varieties were suggested for utilization: eggplant bacterial wilt - all varieties grafted onto resistant rootstock; black rot and downy mildew of cabbage - Spring Light; tomato bacterial wilt - Canner, Star, King Kong; tomato jaune virus - 1104-F7-11, 1104-F7-33, and 1104-FO-27 breeding lines from AVRDC; cucumber anthracnose - Spacemaker; and cucumber *Corynespora* blight - Slicer No. 1 and Green Baron; banana Panama wilt - Valerie, Robusta, Williams and Lacatan.

### 2) Chemical Control of Plant Diseases

A system of foliage fungicide evaluation was established to provide information concerning chemical efficacy, phytotoxicity, application rates, scheduling, etc., under various moisture regimes, on both red lateritic and on sandy soils. Flexibility was designed into the plan to allow for any disease on any host. This system operates as a dynamic living computer generating information throughout the year, every year.

Using this system approach, recommendations were developed for chemical control of *Corynespora* leafspot on tomato and cucumber, bacterial leafspot of bell pepper and tomato, powdery mildew of cucumber, *Cercospora* leafspot of cucumber, and *Paracercospora* leafspot of eggplant.

The project did not successfully develop vegetable rootknot nematode control recommendations during the time covered by this report.

Soilborne and seedling rotting organisms of bush and pole beans were successfully controlled by treating seed with one teaspoon per bushel of copper oxychloride or Benlate.

### 3) Cultural Control of Plant Diseases

Cultural production practices, as well as use of resistant varieties, to control plant diseases, are desired so that reliance on costly chemicals may be decreased. The following cultural efforts were investigated:

a) Solar sterilization of soil - effective against weeds if soil covered for 60 days. There is not enough time for sterilization to control plant diseases and nematodes within the parameters of the Seychelles agricultural economy.

b) Intercrop barriers, such as tall-growing plants - not effective against the plant diseases evaluated, but very effective against insects.

c) Sanitation as exemplified by hand removal of infected leaves. When used on bell pepper Cercospora and bacterial leafspots this was ineffective - must be accompanied by chemical spraying. A fine line is established between removal of too many leaves and yield reduction.

d) Cultural, and chemical guidelines, were developed for the production of healthy, quality vegetable transplants in nurseries.

E) Disease Etiology

The following etiology patterns were investigated.

1) The symptomotology of tomato jaune virus was described.

2) The development of cabbage downy mildew was studied under Seychelles environment.

3) An attempt to relate a specific symptom to very early diagnosis of banana Panama wilt was negated by the symptom being indicative of potassium deficiency instead.

F) Training of Personnel

Training of plant pathology technicians continued as an on-the-job direct contact operation. Additionally, consulting was provided to horticultural technicians.

A program was developed by the plant pathologist for producing vegetable transplants to be sold to the public through a national vegetable transplant nursery. A nursery manager and team leaders were trained to operate this program. Training involved disease control procedures, production scheduling, fertilization scheduling, length of viable sales periods, container types, cultural care in the nursery, etc.

Technicians were specifically trained in procedures for operating a Plant and Soils Diagnostic Laboratory. Additionally a Seychellois counterpart was trained in this area plus the administration of the plant pathology portion. In cooperation with the contract soils scientist, technicians were also cross-trained to minimally operate their companion discipline, if needed.

G) Communication of Research Results

A weekly column concerning items of plant pathological interest was submitted to the Nation newspaper.

Guidelines were developed and published for the production of disease free vegetable transplants.

Developed guidelines for decreasing the confusion concerning the use of fungicides.

Assisted in revision of the quarantine regulations of the Plant Import Permit for the government of Seychelles.

Developed plant disease and insect identification slide sets for use in Seychelles Polytechnic biology classes, and to be used by the national agricultural supply store for display and advertising.

With the local counterpart, developed a series of radio programs in Creole concerning the most important plant diseases in Seychelles.

Developed a vegetable disease packet for FAO representatives interested in hydroponic vegetable production.

Followed up all disease diagnoses with memos or on-site visitation.

Presented a paper at the IXth Africa Horticultural Symposium on Fungicide Evaluation in Seychelles.

H) Miscellaneous

Visited all production areas in Seychelles to familiarize myself with procedures and problems, as well as parastatal groups responsible for growing, distribution, and sales.

Cooperated with contract cohorts whenever possible.

Conducted guided tours of the Soils and Plant Diagnostic Laboratory for youth groups to stimulate their interest in agriculture.

Participated in the planning and operation of the IXth Africa Horticultural Symposium.

LIMERO SANTINYON: _____

DAT KI I TI GANNY SOUMET: _____

PLAN: _____

SORTI KOT: _____

LANDRWA: _____

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REZILTA: _____

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APPENDIX 3: Handbook on Plant and Pest Diseases

# Diseases and Insects of Fruit and Vegetable Crops in the Republic of Seychelles

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# DISEASES AND INSECTS OF FRUIT AND VEGETABLE CROPS IN THE REPUBLIC OF SEYCHELLES

## INTRODUCTION

All fruit and vegetable crops grown in the Seychelles are attacked by many insects and are subject to many different diseases with a wide variety of causes. The productivity of plants declines as insect populations increase on these plants or as diseases increase in severity. Control measures are essential to reduce losses from insect pests and diseases. Correct identification of insect pests and diagnosis of diseases is absolutely necessary for initiation of the most effective control methods for each pest or disease. This is especially important when pesticides are recommended for insect or disease control since it is highly desirable to use the smallest amount of the proper pesticide necessary for control in order to prevent environmental contamination, to prevent the increase in resistance of insects and pathogens to pesticides, to reduce costs and to assure minimum effect on non-target organisms.

One available publication, "Farmers Guide to Pest Control," contains descriptions of diseases and insects of the Seychelles. The descriptions in that publication, however, are brief and are not accompanied by illustrations, which greatly facilitate insect identification and disease diagnosis. In addition, several new diseases of Seychelles recently have been discovered. Descriptions of the symptoms of these diseases have not been published. The descriptions of disease symptoms available to date do not include some of the information relative to symptom development, which is essential to an understanding of the disease, and the basis for control of the diseases.

This publication has been written for use by home gardeners, growers, research workers, technicians, extension personnel and agriculturists in general to supply this new information and to facilitate identification of insect pests, and diagnosis and control of plant diseases of the Seychelles. Recommendations for control of plant diseases constantly are being revised and improved as new pesticides and/or procedures are developed or as new information on control practices becomes available. Consequently, detailed information concerning control is not supplied for all diseases in this publication. This publication should be used in conjunction with the publication entitled "Farmers Guide to Pest Control." Additional information concerning control should be obtained from extension personnel or from scientists at Grande Anse Center.

## DISEASE AND DISEASE DEVELOPMENT

A plant disease is the result of a continuous interaction between a causal agent and a host plant. Deficiencies of factors essential for growth, development and reproduction of the host also may result in disease. Causal agents may be living organisms or some chemical or

physical factor of the environment. The activities of a causal agent (or arrested plant metabolism due to deficiencies) result in physiological dysfunction and/or morphological damage to specific cells, tissues or organs of the plant. Symptoms, characteristic of each disease, develop in response to the activities of the causal agent.

The microorganisms, viroids and viruses that cause diseases are collectively referred to as pathogens, which literally means "a cause of disease." Most living plant pathogens are classified as fungi, bacteria, nematodes, mycoplasmas, viruses or viroids. These viruses, viroids and microorganisms that obtain their nourishment from other organisms are referred to as parasites. The plant within which the parasite is developing is supplying nourishment for the growth, development and reproduction of the parasite and is referred to as the host. Symptoms develop in host tissues in response to the continued activities of the parasite. As a result of this response, the parasite is referred to as a pathogen, since it has caused a disease in the host.

## FUNGI AS PLANT PATHOGENS

The majority of plant pathogenic fungi produce large populations of a wide variety of spores (specialized propagative cells formed by sexual or asexual reproduction), which are capable of initiating the disease process in host plants. These spores are produced as the fungus completes its active growth cycle in the diseased host. The spores, or other propagative units, are disseminated to healthy plants by air, water, insects or mechanical means where they germinate by the formation of a minute germ tube or by development of mycelium from other propagative units.

The germ tube penetrates into the tissues of the host and branches to form a network of end-to-end joined cells referred to as mycelium. The individual cells of the mycelial network secrete enzymes, which decompose or break down the chemical constituents of the cells of the host. These products of chemical decomposition from the host provide the nourishment necessary for the fungus to continue to grow into the host. Chemical reactions that are essential for normal plant cell development are blocked by the enzymes secreted by the parasite. Chemical structures of the host cell walls and cytoplasm also are destroyed by the enzymic activities of the parasite. The result of these processes between the parasite and the host is the development of symptoms.

The activities of each pathogen on its host result in the development of symptoms characteristic of each host-pathogen association. Symptom recognition, therefore, is the basis of disease diagnosis.

The completion of the colonization and growth phase of the pathogen in host tissues is followed by sporulation of the pathogen. Specialized structures of the pathogen are formed as branches of the mycelium or as specialized aggregates of cells on the mycelium upon which or within which the reproductive propagules (spores) of the fungus pathogen are produced. These spores commence the disease cycle over again. The spores and the structures within which or upon which they are formed

are the morphological features essential for establishing the identity of the pathogen.

## BACTERIA AS PLANT PATHOGENS

The processes by which pathogenic bacteria cause symptom development in plants are similar in many ways to those described for fungi. There are, however, many features characteristic of bacteria which distinguish them from fungi. Bacterial cells are much smaller than the cells produced by most fungi, and bacterial cells are produced singly as individuals rather than in chains of cells, which make up the mycelium of the fungi. None of the plant pathogenic bacteria produce spores, but survive as individual bacterial cells in host tissue from season to season.

The bacterial cell does not germinate to form a germ tube and, consequently, is not in possession of a mechanism for direct penetration of the host. Bacterial cells must be introduced into host tissues by insects, which carry the cells from host to host, or must rely on natural openings in the host, such as stomates in the leaves. Injuries also provide avenues of invasion for bacteria to penetrate the host plant. Pruning wounds, cultivation damage and insect feeding injuries are some examples of injuries that may provide infection courts for plant pathogenic bacteria.

Bacteria multiply very rapidly by cell division within the substomatal chamber or in the intercellular spaces once they gain entrance to the host plant. Enzymes and other physiological activities of the bacteria cause rapid destruction of host cells and tissues resulting in symptoms characteristic of each bacterial disease.

Bacterial plant pathogens survive in host debris in the soil, in insect vectors and in woody tissues of diseased plants upon completion of the disease cycle. Some bacteria have weed hosts, which are important for their survival in the intervals when crop host plants are not being grown.

Dissemination of bacteria occurs in wind-blown rain, which removes bacterial cells on exposed surfaces of diseased hosts and carries them to healthy plants. Bacteria that contaminate pruning tools also are introduced to new hosts as pruning operations are carried out. Insects may pick up bacteria on mouthparts, bodies or legs as they feed on diseased plants and carry the bacterial cells to new host plants. Contaminated cultivating tools will carry bacteria from one location to another. Many bacteria are seed-borne and will invade seedlings that grow from contaminated seeds. Vegetative propagating units, such as stem cuttings, grafting scions, or root or tuber sections, may be infected with bacteria. These bacteria may be disseminated to new areas and develop in the host with the growth and development of the propagating material.

## NEMATODES AS PLANT PATHOGENS

Nematodes (roundworms or threadworms) are another large group of destructive plant pathogenic microorganisms. The ways in which

nematodes attack plants and cause diseases are very different from the ways in which bacteria and fungi carry out these activities. These differences are partly a reflection of the structural differences between the various organisms since nematodes are structurally more complex than fungi and bacteria. Methods of obtaining their food and the types of life cycles also are very different for nematodes as compared to fungi and bacteria.

Plant parasitic nematodes are multicellular microorganisms in which highly specialized groups of cells are united into cell systems or tissues to carry out specific functions essential to growth, development and reproduction of the individual nematode. No such complexity of cells or cell organization and specialization exists in fungi and bacteria.

The life cycle of nematodes commences as an egg, which hatches as the young larvae leaves the egg. The larvae are able to migrate for a few centimeters in the soil to the tips of young plant roots. The nematode gains entrance to the root by probing the epidermal and cortical cells of the host root with the stylet. The stylet is a hollow, rigid, pointed structure situated in the mouth of the nematode.

Host-cell contents are broken down by enzymes secreted by glands in the mouth of the nematode and are taken into the nematode digestive system through the stylet. These substances constitute the food for the nematode and are further digested in the digestive tract. The products of digestion are absorbed into the circulatory system in the interior cavity of the nematode from the digestive system. These substances then nourish a variety of nematode tissues, which enables the nematode to move, grow and to reproduce.

Many species of nematodes do not penetrate into the plant root, but continue to feed on the outer layers of the root system. Nematodes that live in this manner are referred to as ectoparasites. Nematodes that do penetrate into and survive within the host tissues are endoparasites.

Symptoms develop on host plants parasitized by large populations of nematodes. The feeding activities of the nematodes interfere with normal water and mineral nutrient absorption and translocation by the root. Consequently, the first symptoms of nematode damage observed are wilting and a yellow discoloration of the leaves. In cases of severe infection, the plant will be dwarfed in size as a consequence of the detrimental activities of the pathogen in the roots. These symptoms are referred to, consequently, as secondary symptoms.

Feeding activities by nematodes also result in primary symptoms on the roots themselves. Pathogenic activities of many nematodes result in the development of dark areas of discoloration (a symptom referred to as a necrotic lesion), or lead to the formation of galls or irregular growths and deformation of the root. In other cases necrotic lesions may be formed within the roots as nematodes burrow into the root tissues.

The females lay eggs as the nematode life cycle nears completion. Many species deposit eggs near or on the surface of host roots. Other species deposit eggs inside of the roots. In the latter case the eggs are

released as the root decomposes.

Nematodes are capable of independent movement for only a centimeters in the soil. In addition, their movement is determined by moisture content, with independent movement decreasing as moisture content decreases. Consequently, dissemination of ne todes occurs by movement of eggs or larvae in irrigation water o running water from rainfall. Nematodes also are disseminated in clinging to shoes or cultivating implements. Nematode-infested moved from place to place with transplants is another impor method of dissemination. Transplants infected by nematodes will in duce the pathogen into new areas.

Nematodes also will be transferred from place to place in (or infected vegetative propagative units such as tubers, corms or ro The crop that develops from these infected plant parts may deve disease symptoms and suffer reduced yields. In addition, it will pro a source of inoculum for future crops, which may be susceptible to nematode.

## MYCOPLASMAS AS PLANT PATHOGENS

Mycoplasmas, the smallest microorganisms identified at this ti are causal agents (pathogens) of many plant diseases. The absenc a cell wall around the individual mycoplasma cells is another cha teristic that distinguishes them from other microorganisms. These nute pathogens are transmitted by leafhoppers, which feed by mean piercing sucking mouthparts in the phloem tissue of plant lea Individual cells of the mycoplasmas are taken up as the leafhopp feed. The leafhopper then may fly to a healthy plant and, in the proc of feeding, introduce the mycoplasma cells into the phloem cells of new host. The mycoplasmas colonize th cells of the phloem, re duce and migrate into new cells. The activities of the mycopla interferes with or terminates the normal biochemical activities of host cells. Symptoms then develop in the infected plant.

The yellows diseases (frequently referred to as aster yellows) is term applied to a general yellow discoloration of the leaves of pl infected by mycoplasmas. The yellows diseases are the most com of the diseases with a mycoplasma as an etiologic (causal) a (pathogen). Lethal yellowing of coconut palms is a mycoplasma-cau disease responsible for serious economic losses in some areas of world. The leaves of infected palms turn yellow in color, and formation of new leaves is curtailed. The infected palms ultimately The mycoplasma responsible for lethal yellowing has been shown t transmitted from diseased to healthy palms by a leafhopper. disease is not known to occur in Seychelles. Other symptoms cha teristic of mycoplasma infection include dwarfing, witches broom false-blossom.

Mycoplasmas are suspected of causing several diseases in Seychelles. The identities of the pathogens of these diseases ne have been proved.

## VIRUSES AS PLANT PATHOGENS

Viruses are not organized as individual cells or as united cellular units, as is true for the microorganisms, such as fungi, bacteria, mycoplasmas and nematodes, which cause diseases of plants. Consequently, viruses are not classed as microorganisms. The viruses are complex combinations of polymerized (joined end to end) nucleic acid chemical molecules enclosed within a layer of protein molecules.

Viruses are complex chemical units and, as such, do not possess the ability for independent movement from infected to healthy plants. Viruses are not disseminated by air currents nor by running water, and, consequently, are dependent upon some agent of transfer (transmission) from plant to plant. Viruses may be transmitted in scions or buds used for grafting. Some viruses are transmitted in infected vegetative propagating materials, such as potato seed pieces, cassava canes, and sugar cane or sweet potato shoots. Many viruses are transmitted by insects which feed on infected plants and, as a consequence of feeding, obtain virus particles. The insect then may fly to a healthy plant where feeding commences. The virus is introduced to the healthy plant as the insect feeds, and will then parasitize and cause disease in the new host. Many viruses are seed-transmitted and will move into seeds that develop on infected plants. The virus will then invade the leaves of the seedling as growth commences and continue to develop in the growing plant, resulting in symptom production. The spores of a few root-infecting species of fungi become contaminated with virus particles in doubly infected plants. The virus is released into the root cells of healthy plants when the fungus invades these roots. Consequently, the plants become infected by the virus. None of the viruses (represented by lettuce big-vein virus and tobacco necrosis virus) transmitted in this fashion are known to occur in Seychelles.

Mechanical transmission is yet another way in which viruses gain access to healthy plants from infected plants. Virus particles adhere to cultivating equipment or to workers as plants are bruised in day-to-day field operations. Injury to healthy plants followed by deposition of virus particles results in infection. Mechanical transmission also may occur if pruning tools become contaminated with virus particles prior to being used to prune healthy plants.

The protein coat of viruses is shed as the virus is introduced to the host plant cell. The nucleic acid (infective) portion of the virus molecule then attaches itself to internal organelles or structures of the host cell where it directs the cell to produce additional virus nucleic acid and protein. These new virus particles are released from the diseased cell and penetrate new cells to continue the cycle of infection.

Viruses interfere with physiological (biochemical) reactions in plant cells and tissues in ways that are different from the ways in which fungi, bacteria, mycoplasmas and nematodes affect plants. Consequently, many symptoms that develop as a result of virus infections are very different from those induced by microorganisms. A mosaic symptom, characterized by alternating bands or patches of various shades of

yellow and green colors, is the most typical and most frequently occur ring symptom of virus diseases. Leaves of plants infected with viruse may develop long, spindle-shaped lobes (or the entire leaf may be mucl longer and narrower than normal). This symptom is referred to as strap leaf, since the infected leaves assume the narrow, long appearance of a strap. Some viruses result in downward curling or a "cupping," referre to as epinasty of infected leaves. Other symptoms of virus disease include necrotic ringspots, plant dwarfing, leaf stunt, anthocyanes cence (purple discoloration) and fruit deformation.

## VIROIDS AS PLANT PATHOGENS

Viroids are the smallest known causes of infectious diseases. The are composed of very short (small) units of nucleic acid and do no possess a protein coat, as is characteristic of viruses. Viroids ar transmitted mechanically and in plant propagative units used for graft ing. Mechanical transmission occurs when leaf cells of infected plant are bruised by persons or implements moving past the plants. Viroi particles released from host cells by bruising adhere to passing object and are brushed onto healthy plants. The viroid particle gains entranc to healthy cells through injuries and establishes itself in the healthy cell This initiates the infection sequence. Viroids that contaminate prunin tools can be introduced to uninfected plants in pruning operations Viroids also are transmitted to uninfected plants when scions or buds o infected plants are used for grafting.

Viroids have been demonstrated to cause diseases such as ho stunt, avocado sun blotch, cucumber pale fruit, tomato bunchy top cadang-cadang disease of coconuts, potato spindle tuber, chry santhemum stunt, citrus exocortis, chrysanthemum chlorotic mottl and citrus tristeza.

No viroid-caused disease has been identified to date in Seychelles

## NUTRIENT DEFICIENCIES

There is no true pathogen or "disease-causing agent" for deficienc diseases. All plants require minimum quantities of several nutrient (chemical ions), such as nitrogen, phosphorus, potassium, calcium magnesium, iron, zinc, manganese, copper and several others, fo normal growth, development and reproduction. Symptoms of defi ciency disease develop in plants whenever the plant is unable to obtai sufficient quantities of these nutrients to maintain normal health. The symptoms displayed by nutrient-deficient plants reflect the specific nutrient that is deficient and are indicative of the role of the nutrient in the metabolism of the plant. Nutrients are obtained by plants through the roots by absorption from the soil solution. Many soils (especially sanc soils) may be deficient in one or more nutrients, and consequently, the amount of certain nutrients obtained by the roots may be below the quantity required for the nutrition of the plant. On the other hand nutrients may be present in the soil in quantities sufficient for the minimum nutritional requirements of the plant, but they may be chem-

ically bound (combined) in a chemical compound that is insoluble, and therefore, not available to be taken up by the roots.

Plants may develop symptoms of nutritional deficiency if the root systems have been attacked by pathogenic bacteria, fungi or nematodes, or by insects. In these situations, there may be an abundance of soluble mineral nutrients in the soil solution. The functional efficiency of the roots for absorption of the nutrients, however, may be sufficiently impaired by the activities of the pathogen to prevent uptake of nutrients in amounts adequate to supply the minimum nutritional requirements of the host. Nutritional deficiency symptoms will then appear on the plants.

## SAFE USE OF PESTICIDES

All plants are attacked by a wide variety of disease-causing agents, such as fungi, bacteria and nematodes; insects, slugs and mites feed on crop plants. Weeds compete with cultivated plants for nutrients, moisture, space and sunlight. These organisms are all classified as pests, since they compete with man for the food from the plants he grows for his food. A wide variety of chemicals have been developed for control of these various pests of man's crops, and since they are purposely designed to control pests, are referred to as pesticides, which literally means "a killer of a pest." Pesticides are classified in several ways, one of which identifies the type of pest to be controlled. Insecticides are designed for insect control, miticides (acaricides) for mites, nematicides for nematodes, fungicides for fungi and herbicides for weed control.

Pesticides are essential chemical tools for maximum agricultural production. They are manufactured specifically to kill certain pests and, since they are toxic compounds, pose health hazards to non-target organisms including man. The utmost caution, consequently, must be employed in using pesticides, in cleaning up after use, and in disposal of unused pesticides and pesticide containers.

The publication entitled "Farmers Guide to Pest Control" contains detailed information on safe use of pesticides, pesticide toxicity, first aid, instructions for application and definitions. That publication should be consulted for additional details on pesticide use and safety precautions.

1. The toxicity of a pesticide is determined by the type of active ingredient (chemical). The toxicity of the final formulation of the pesticide is determined by the active ingredient and by the concentration of the active ingredient in the formulation. Pesticides differ in their toxicity to man. Consequently, it is important to purchase the "safest" chemical (the one with the lowest mammalian toxicity and the least amount of active ingredient) that will accomplish the desired control results.
2. The quantities of pesticides purchased frequently exceed the amounts actually required for control of the pests for which the

chemical is intended. The pesticide remaining poses disposal and/or storage problems. Disposal of pesticides generally results in some degree of contamination of the environment since the pesticide may be poured on the soil surface or into a hole in the soil. Rain will distribute the chemical over the soil and may ultimately carry it to ground and/or surface water. Stored pesticides pose potential hazards to children, may deteriorate with time, or may corrode containers and result in leakage.

The quantity of each pesticide needed for specific purposes should be determined prior to purchase. Purchases should be limited to the least amount of pesticide necessary for immediate use. The quantity necessary can be determined by obtaining information from extension officers, from "Farmers Guide to Pest Control," or from information in this publication concerning the amount of pesticide to be used on a given area of crop at each application and estimating the numbers of required applications.

Pesticides should be stored in non-breakable, corrosion-proof containers with clearly visible warnings of poison hazard, ingredients and instructions for use. Pesticides should be purchased in original containers whenever possible; the practice of re-packaging and re-labelling should be discouraged. Stored pesticides should be isolated from other materials, should be inaccessible to children, and should be in locked storage.

Pesticides in storage should be inventoried from time to time. Old pesticides and those with unreadable labels should be disposed of. Empty containers should be burned or crushed and buried. Pesticide containers should never be used for storage of materials other than pesticides. Pesticides should never be stored in any containers other than those designated for such use.

3. Pesticides remaining in the sprayer after application also pose disposal problems. Determine the amount of pesticide required to treat the area involved, and prepare only enough pesticide for the intended purpose. Any material remaining in the sprayer should be applied over the area if only a small amount is left over. Otherwise it will be necessary to dispose of the pesticide remaining by dumping. Caution in cleaning the sprayer also must be exercised.

4. Accidental contamination of skin or eyes by pesticides or inhalation of spray are the most dangerous and most highly probable consequences of use of pesticides. Consequently, gloves and a minimum of protective clothing should be worn. Eye protection also must be used when applying pesticides.

   Always apply pesticides downwind so that any drift moves away from the applicator. Do not apply pesticides during periods of breeze or wind.

5. The quantity of pesticide remaining on the plant at harvest is referred

to as residue. The amount of residue is determined by the amount of pesticide applied at each application, the number of applications and characteristics of the weather, especially rainfall, during the crop season. Residues present at harvest also are influenced by the type of pesticide, since some pesticides decompose more readily than others, and by the length of time between final spray and harvest.

Recommendations for most pesticides specify a minimum number of days between final application and harvest. These time intervals vary between 0 and 90 days, depending upon the persistence of the pesticide. Some pesticides are for use only on non-edible portions of plants; others should not be used on any plants that are to be used for food (i.e., they are only for use on ornamental plants). All plant parts to be eaten should be thoroughly washed if pesticides have been used on the plants.

6. Many diseases can be controlled by methods other than, or in addition to, the use of pesticides. These methods include crop sanitation, crop rotation and use of resistant varieties. These methods should be employed whenever possible. The use of pesticides should be kept to an absolute minimum.
7. A wide variety of pesticides are available for crop protection. Most pesticides are most effective against a limited number of pests. In some cases a pesticide may not be at all effective in controlling some pests. It is essential, therefore, that information be obtained from extension personnel or pest control officers concerning the pesticide with maximum effectiveness for each pest.

## GENERAL RECOMMENDATIONS FOR FUNGICIDES

The general recommendations presented here are based on the latest manufacturer's information. The amount of the fungicide to be used from the package is determined by the concentration of the fungicide as percent of active ingredient (a.i.) in the packaged product. Fungicides with active ingredient concentrations other than those listed may be available in Seychelles. The recommendations for rates of application of these formulations will differ from those given. Fungicides not listed here may be available to growers in Seychelles. The rates of use of these categories of fungicides should be obtained from product label descriptions, from extension or research personnel or from other publications, such as "The Farmers Guide to Pest Control."

The information provided in the first column of the table includes the trade name of the fungicide product, the percent of active ingredient, whether the product is formulated as a wettable powder (WP), flowable (F) or liquid concentrate (LC), and the name of the active ingredient. The recommended amounts (in grams or milliliters) of fungicide product per liter (l) of water are listed in the second column. The number in the third column is the time interval in days that must be allowed between the last application and harvest.

| Fungicide | Rate/l | Waiting period (days) |
|---|---|---|
| Bayleton 50WP<br>triademefon | 0.23 g | 7 |
| Benlate 50WP<br>benomyl | 1.2 g | 14 |
| Bravo 75WP<br>daconil<br>chlorothalonil | 2.4 g | 7 |
| Bravo 40.4LC<br>chlorothalonil | 3.4 ml | 7 |
| Difolatan 39F<br>captafol | 3.7 ml | — |
| Dithane M-22 80WP<br>maneb | 2.4 g | 7 |
| Dithane M-45 80WP<br>mancozeb | 2.4 g | 7 |
| Karathane 19.5WP<br>dinocap | 0.6 g | 7 |
| Karathane 37.4LC<br>dinocap | 0.3 ml | 7 |
| Manzate 200 80WP<br>mancozeb | 2.4 g | 7 |
| Orthocide 50WP<br>captan | 2.4 g | — |
| Phaltan 50WP<br>folpet | 2.4 g | -- |
| Ridomil MZ 58WP<br>metalaxyl +<br>mancozeb | 2.4 g | 5 |

## CONVERSION FACTORS AND CONVENIENT MEASUREMENTS

| | |
|---|---|
| 1 ounce | 28.35 g |
| 1 pound | 453.60 g |
| 2.2 pounds | 1kg |
| 1 teaspoon | 5.5 ml |
| 1 fl. ounce | 29.6 ml |
| 1 pint | 473.0 ml |
| 1 quart | 946.0 ml |
| 1 gallon | 3,785.0 ml |
| 1 teaspoon Benlate | 1.6 g |
| 1 teaspoon Bravo | 3.5 g |
| 1 teaspoon Bayleton | 1.8 g |
| 1 teaspoon Dithane M-22 | 2.7 g |
| 1 teaspoon Karathane | 2.5 g |
| 1 acre | .405 ha |
| 1 ha | 2.47 acres |

## GLOSSARY

**Anthracnose** — A stem or leafspot disease in which conidia of the fungus are produced in an open lesion.

**Ascospore** — A spore produced in an ascus by sexual reproduction in many fungi.

**Ascus** — A sack-shaped structure within which ascospores are produced.

**Blight** — A symptom of a plant disease in which large areas of leaves, stems or flowers are rapidly killed.

**Blotch** — A symptom characterized by irregular patches or spots on leaves, stems and shoots.

**Canker** — A necrotic lesion formed on the stem, branch or twig of a host.

**Chlorosis** — A symptom characterized by development of a yellow color on normally green plant parts.

**Cleistothecium** — A small, black, spherical, closed structure containing asci and ascospores. Cleistothecia frequently are produced by powdery mildew fungi.

**Concentric** — A pattern characteristic of many leaf spots in which one circle of diseased tissue is surrounded by others around a common center.

**Conidiophore** — A specialized branch (hypha) of fungus mycelium that produces conidia.

**Conidium** — A specialized spore (reproductive unit) of fungi produced on a conidiophore by asexual reproduction.

**Damping-off** — A symptom of disease in which seedlings wilt, fall over and die. A dark brown to black area of dead stem and upper root tissue at the soil level usually will be present.

**Debris** — Plant material remaining after harvest or death of plants.

**Defoliation** — Loss of leaves by a plant.

**Dieback** — A symptom of a plant disease in which leaves and stems die from the tip of the shoot toward the base of the plant.

**Disease** — Any continuous upset in the processes in plants that interferes with normal structure or function.

**Disease cycle** — The sequence of events in the development of disease from initial infection through symptom development.

**Dissemination** — The transfer of inoculum from its source to healthy plants.

**Dormant** — An inactive or "resting" stage of any organism.

**Downy mildew** — Any of a group of plant diseases caused by a certain group of fungi in which the spores and spore-bearing structures form externally as a white, downy growth on the lower surface of infected leaves.

**Dwarf** — A symptom in which plant parts are much reduced in size.

**Epidermis** — The outer layer of cells covering leaves and other plant organs.

**Fungus** — An organism composed of undifferentiated cells which lack chlorophyll. The vegetative body of fungi generally is organized into a network of mycelium.

**Gall** — An enlargement or swelling of part of a plant organ caused by response to infection by many pathogens.

**Germ tube** — The small, thread-like structure that grows from fungus spores as germination occurs. The germ tube is the structure that penetrates into the plant to initiate infection in fungus-caused diseases.

**Halo** — A ring of yellow tissue around a leaf lesion.

**Haustorium** — A specialized branch of fungus mycelium that penetrates into host cells and functions as an absorbing structure.

**Host** — A green plant from which a parasite obtains its nourishment.

**Hypha** — A single strand of cells or branch of fungus mycelium.

**Incidence** — A measure or estimate of the amount of disease present, expressed as the number (or percent) of diseased plants in a population.

**Infection** — The establishment of a pathogen within the host.

**Inoculate** — To bring a pathogen together with its host plant.

**Inoculum** — Pathogen structures capable of establishing infection in a host plant.

**Intensity** — A measure or estimate of the disease present on specific organs or parts of plants, usually expressed as percent of leaf area diseased.

**Interveinal** — Discoloration developing between the vines of leaves of diseased plants.

**Invasion** — The development of a pathogen into the tissues of the host.

**Leaf spot** — A small, local area of a leaf characterized by yellow to brown to black color. A leaf lesion.

**Lesion** — A local area of diseased, discolored tissue. A leaf spot is a type of lesion.

**Mold** — The growth of a fungus on organic material. The mycelium and spores of the fungus on organic matter.

**Mosaic** — A symptom of disease (especially virus diseases) in plants in which leaves develop alternating bands or patches of various shades of yellows and greens.

**Mycelium** — The network of fungus cells or hyphae which make up the body of a fungus.

**Necrotic** — A general type of symptom in which cells or tissues are killed and usually become brown to black in color.

**Nematode** — Small, worm-like animals with cells united into complex tissues. Many nematodes cause diseases of plants.

**Obligate parasite** — An organism that must develop in a living host for survival.

**Oospore** — A specialized, thick-walled spore of certain fungi produced by a sexual reproductive process.

**Parasite** — An organism that obtains its nourishment from a living plant (or animal).

**Parenchyma** — Thin-walled, chemically active cells, which make up many of the tissues in plants.

**Pathogen** — An organism that may invade a plant and result in the development of symptoms, i.e., cause disease.

**Penetration** — The initial invasion of a host by a pathogen.

**Powdery mildew** — Any of a group of diseases in which the mycelium and spores of the fungus pathogen develop superficially on the host to impart a white, powdery appearance to the host.

**Pycnidium** — A small, black, globose to flask-shaped, cellular fungus structure in which conidia are produced.

**Resistant** — A host plant that cannot be attacked by a pathogen.

**Rot** — A symptom characterized by the appearance of soft, slimy, decomposition of the succulent portions of the host.

**Rust** — A type of disease in which small "rusty-red" structures appear on infected leaves.

**Sanitation** — A method of disease control carried out by removal or destruction of host plant remains containing pathogen structures in order to reduce the amount of inoculum of the pathogen.

**Saprophyte** — An organism that obtains nourishment for growth, development and reproduction from organic debris.

**Scab** — A rough, irregular lesion that develops on host organs as a result of invasion by a pathogen.

**Sclerotium** — A small, hard, brown to black fungus structure composed of compact hyphae.

**Scorch** — A necrotic symptom characterized by rapid death of leaf margins or entire leaves.

**Sign** — Any direct indication of the physical presence of a pathogen on diseased tissue. Signs are specific pathogen structures such as spores, pycnidia, mycelium, sclerotia, etc.

**Spore** — The reproductive or propagative unit of fungi consisting of one or more cells. Spores are produced as a result of sexual or asexual processes and function as inoculum to perpetuate the fungus.

**Stomate** — A small, natural opening between specialized cells in leaves, which permits gas exchange between the inside and outside of the leaf.

**Strap-leaf** — A symptom characterized by leaves that are much longer and narrower than those on healthy plants.

**Stunt** — A symptom in which diseased plants are arrested in growth.

**Susceptible** — A condition in which a plant can be attacked (invaded) by a pathogen.

**Suscept** — A plant that can be invaded by a pathogen. Not resistant.

**Symptom** — The visible response of a host plant to the harmful activities of a pathogen. Examples of symptoms are leaf spots, twig cankers, leaf blights, flower blights, soft rots, leaf wilt, chlorosis, stunting, leaf curl.

**Translocation** — The movement of water and solutes in the vascular system of green plants.

**Transmission** — The transfer of inoculum from a diseased to a healthy plant. Vectors frequently are important agents of transmission.

**Urediospores** — Small, orange to "rusty-red" spores produced by rust fungi.

**Vascular** — The tissues in plants through which water and minerals move from roots to the leaves (xylem) or through which sugars move from leaves to roots (phloem).

**Vector** — A biological agent responsible for carrying or transporting inoculum of a pathogen from an infected to a healthy plant. Aphids and leafhoppers frequently are vectors for viruses. Beetles may be vectors for some bacteria. Some nematodes may be vectors of certain viruses.

**Wilt** — A symptom of disease in which the leaves droop downward. Indicates a lack of adequate water in the leaves.

**Zoospore** — A small, motile spore produced by many species of fungi.

# Diseases

**Disease:**
**BACTERIAL CANKER**

**Hosts:** Sour orange *(Citrus aurantium)*, sweet lime *(C. limettioides)*, lemon *(C. limon)*, grapefruit *(C. paradisi)*, sweet orange *(C. sinensis)*, trifoliate orange *(Poncirus trifoliata)*

**Pathogen:** *Xanthomonas citri (X. campestris* pathovar. *citri)*

Tahiti lime *(Citrus latifolia)*, calamondin *(C. madurensis)*, citron *(C. medica)*, mandarin orange *(C. reticulata)* and several species of kumquat (*Fortunella* spp) are resistant to *X. citri.*

**Symptoms:** The initial leaf symptom is a small, dark-green, circular lesion with a chlorotic halo. The margin of the lesion becomes brown, raised and somewhat "corky" as symptom development continues. The center of the lesion becomes tan to gray at maturity with a persistent chlorotic halo around the outside of the lesion. Fruit lesions resemble leaf lesions, except that the halo is not present. The development of raised, "cork" cells on the fruit causes a "scabby" appearance. The bacterium enters the twigs primarily through wounds caused by insects or pruning, etc. The dark-colored, elliptical twig lesions ultimately rupture to form a typical canker on the twig. The pathogen may girdle small twigs as it continues to develop in the tissue. The movement of water into the portion of the branch above the lesion is restricted and, consequently, the leaves wilt and die, resulting in a twig-blight or dieback symptom.

**Control:** The pathogen survives in infected twigs and produces masses of bacteria in droplets of mucilagenous fluid when the cankers are wet for any length of time. Control by pruning diseased wood, therefore, is important to eliminate the dead wood and also to destroy the source of inoculum. The prunings should be burned. Pruning tools should be disinfected in a clorox solution during these operations. Application of copper sprays to fruit during early stages of development may provide some control. The bacterium survives in infected leaves and, consequently, sanitation by destruction of these leaves should be practiced whenever possible.

**Disease:**
**BACTERIAL BLIGHT OF BEAN**

**Host:** Garden beans *(Phaseolus vulgaris)*
**Pathogen:** *Xanthomonas phaseoli*

**Symptoms:** The pathogen responsible for this disease invades leaves, stems, pods and seeds. The leaf symptoms first appear as small, water-soaked or light green patches. The lesions enlarge as symptom development progresses, and the centers become dry and brown. These lesions are irregular in size and shape and are surrounded by an irregular yellow border. The individual lesions will continue to enlarge; several lesions may coalesce to result in large lesions, which may occupy a major portion of infected leaves. These infected areas will be rust-red to brown in color, with some chlorosis around the margins of the lesions. The term bacterial blight is applied to this disease because of the large amount of leaf tissue which may be killed in a short time by the pathogen.

Small, water-soaked, dark green lesions develop on infected pods. Individual lesions will coalesce as the bacteria continue to develop in the pod tissue to form large, irregular red to red-brown lesions. In cases of severe infection the pod may shrivel and die.

*X. phaseoli* may invade the developing seeds from infected pods. These seeds may be brown and shriveled when results of infection are severe. In other cases individual sunken, brown lesions will develop. In some cases, especially when the seeds are infected late in development, no distinct lesions will be observed on the seeds.

Bacterial cells are disseminated in infected seeds and will cause disease in seedlings that grow from these seeds. These symptoms appear as sunken, brown, necrotic stem lesions or as typical leaf lesions.

Symptoms of halo blight (caused by *Pseudomonas phaseolicola*) are similar in many respects to those resulting from *X. phaseoli* under high temperatures. In general, however, the *P. phaseolicola* leaf symptom is a small (2 to 4 mm), circular, necrotic leaf spot with a chlorotic halo. Halo blight has not been identified in Seychelles as of this writing.

**Control:** The use of seed known to be pathogen-free is of the utmost importance. The bacterium is thought to survive in host debris on the soil. Removal of this plant material and good cultivation to bury the dead leaf and stem tissue also are recommended control practices. As a general rule, bacterial blight can be expected to threaten bean crops whenever one bean crop follows another and good soil tillage-cultiva-



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tion practices are not carried out. The cells of the bacterium may be disseminated by water droplets. Moisture also is essential for infection by the bacterium. Irrigation should be carried out in the early morning hours, whenever possible, to allow the leaves to dry as rapidly as possible during the day. Surface, rather than overhead, irrigation also may reduce the severity of this disease.

Copper sprays applied four or five times during the crop season have been found to provide some control of this disease. Basic copper sulfate at 5.0 g/l and Kocide 101 (Cupric hydroxide; 56% Cu) at 2.5 g/l are two copper-containing fungicides which have proved successful.

Some varieties are resistant and should be grown wherever this disease is a problem.

**Disease:**
**BACTERIAL LEAF SPOT of TOMATO AND PEPPER**

**Hosts:** Tomatoes *(Lycopersicon esculentum)* and peppers *(Capsicum annuum* v. *longum)*

**Pathogen:** *Xanthomonas vesicatoria*

**Symptoms:** Small (1-3 mm), yellow leaf lesions are the first symptoms of bacterial leaf spot. The center of these lesions will turn gray to tan in color as the leaf cells die. This gray, necrotic center will be surrounded by a narrow black border. A small chlorotic halo may appear around the lesion as bacteria continue to develop into the leaf cells surrounding the original lesion. The individual lesions will continue to enlarge to about 4-5 mm in diameter, and will become tan to brown in color; some black discoloration may be associated with the margins of some of the lesions. Mature lesions may grow together, resulting in large patches of brown-grey, dead leaf tissue. Water loss from these areas will result in a buckling or curling of the leaf. In cases of severe disease, these leaves may drop from the plant. Bacterial cells produced on these lesions will be spread by splashing rain, cultivating implements or insects to uninfected leaves. They will multiply on these leaves to produce more cells, which will then penetrate the leaf through stomates, hydathodes or injuries to initiate the infection cycle over again.

Infection of tomatoes and peppers also may occur on petioles of the leaves, fruit peduncles, on the calyxes of flowers or on the fruits. Fruit lesions commence as small, pin-point size, black spots. These lesions enlarge to 3-4 mm in diameter and become brown in color and slightly raised with a "scab-like" appearance.

**Control:** Control of bacterial leaf spot is very difficult under most growing conditions in Seychelles, but is especially difficult under conditions of long periods of overcast skies with rain and moderate winds. *X. vesicatoria* will survive for many months in old leaf debris remaining in the field after harvest. Several control measures are based on this characteristic of the pathogen. Sanitation, involving removal and destruction of diseased leaves and plants at harvest, should be practiced. Land which has been planted to peppers or tomatoes should be thoroughly tilled to bury old plant debris prior to re-planting. Rotation away from peppers or tomatoes for two or three crop sequences may be advisable.

Use of resistant varieties may provide control of this disease. Neptune and Pluto varieties of pepper have proved susceptible in Seychelles. Solar King, introduced as a resistant variety, also was found



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to develop typical symptoms.

The bacteria causing this leaf spot disease are disseminated to host plants by wind-driven rain, insects and cultivating implements. The bacteria divide on the leaf surface and then invade the host leaf through stomatal openings or injuries. Sprays of copper oxychloride plus Dithane M-45 at 3-4 day intervals may kill these bacteria before they enter the leaf. Sprays of 200 ppm of streptomycin sulfate (8.2 g/l per 100m) have proved effective for control of this disease.

Infection of leaves by the leaf spot bacterium is influenced by moisture on the leaf. Consequently, cultivating and picking operations should not be carried out when the plants are wet. Irrigation water should be applied to the soil, rather than by sprinkler over the plants.

*X. vesicatoria* contaminates and is disseminated on seeds. Seeds from disease-free plants should be used for seedling production. Soaking seeds in sodium hypochlorite (available as a 5.25% solution of NaClO under trade names such as Javel or Clorox) mixed 1 part to 4 parts water for 40 minutes will provide control of this inoculum. Seeds should be spread and air-dried as soon as treated. Disease-free transplants should be used; seeds should be sown in sterile soil, or in soil with no previous history of peppers or tomatoes with bacterial leaf spot disease.

**Disease:**
**BACTERIAL WILT**

**Hosts:** Tomatoes *(Lycopersicon esculentum)*, peppers *(Capsicum annuum)*, eggplant *(Solanum melongena)* and many others

**Pathogen:** *Pseudomonas solanacearum*

**Symptoms:** Wilting of the tip of infected plants is the initial symptom. This symptom becomes progressively worse with time, especially under hot, dry conditions. Some chlorosis of the leaves may occur, but this is not as pronounced as in plants with Fusarium wilt. The leaves die and turn brown as the disease becomes more severe. Infection through the juvenile stages of development generally results in death of the plant before fruits mature. Downward curling of leaves and an increase in the numbers of roots from the lower stem region also occur on infected plants.

A diagonal or lengthwise cut through the lower stem will reveal two tan to brown lines of the vascular cylinder. A cut across the stem frequently will result in a creamy-white, sticky bacterial ooze. In cases of severe infection the bacteria may invade the pith, or central portion of the stem, resulting in a soft rot, which will be brown in color.

**Control:** Cultural practices, such as using disease-free transplants, rotation away from susceptible crops for two years, and keeping soil moisture as low as practical for crop production, are the most important methods of control.

Bacteria in the soil or in old crop debris can be moved from place to place by irrigation water or by cultivating tools. Every effort should be made to prevent dissemination of the pathogen by these means.



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**Disease:**
**BLACK ROT**

**Host:** Cabbage *(Brassica oleracea* v. *capitata)*

**Pathogen:** *Xanthomonas campestris*

**Symptoms:** This disease can occur at any growth stage of the cabbage host. Cells of the black rot pathogen move in the translocation stream of infected plants and may move into seeds of infected plants. Consequently, young seedlings may be infected. Leaves of infected seedlings will turn yellow and wilt as the bacteria invade the vascular system and prevent upward movement of water and nutrients from the roots. The vascular strands in the stem may turn black. This is revealed by cutting diagonally through the stem. Infection in the seedling stages kills many of the seedlings.

The infection process commences as bacteria enter cabbage leaves through wounds or stomates. The bacteria multiply in the leaf, killing large areas. These areas are yellow, then turn brown. The lesions are V-shaped when infection occurs near the veins at the edge of the leaf. The veins frequently become black. Large areas of the head develop a black, slimy symptom referred to as soft rot.

**Control:** The bacteria survive in infected seeds or in plant debris in the soil. They are spread in infected seeds, in diseased transplants, in contaminated soil, by cultivating tools, or by splashing rain or irrigation water. Seeds should be certified as having been produced under disease-free conditions, or the seeds can be (or have been) treated by soaking in hot water at 122 F for 25 minutes. Diseased seedlings should be removed from the seed bed at the first appearance of symptoms. Only disease-free seedlings should be used for transplants. Invasion of cabbage by the bacterium is favored by prolonged periods of free moisture on the plants. Plant beds should be located on well-drained, sunny locations to assure rapid drying of the leaves each morning or after irrigation. Irrigation should be applied in the early morning by surface methods. Cabbage plantings should be kept weed-free. Cultivation should be carried out only when the leaves are dry. Land with a history of black rot should not be used. Generally, a two-year rotation away from cabbage is essential in order to achieve control by this method.



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**Disease:**
**ANTHRACNOSE**

**Hosts:** Papaya *(Carica papaya)*, guava *(Psidium guajava)*, green pepper *(Capsicum annuum* v. *grossum)*, cashew *(Anacardium occidentale)*

**Pathogens:** *Colletotrichum capsici* and *Colletotrichum* sp.

**Symptoms:** *Colletotrichum capsici* has been identified from papaya and pepper fruits with anthracnose. *Colletotrichum* sp. has been identified from diseased guava and cashew fruits.

Small, sunken, circular to elliptical lesions appear at various locations on mature fruit with anthracnose. The color of the initial lesion may be slightly darker than the surrounding fruit tissue during the early stages of symptom development. This color difference produces a water-soaked appearance in the immature lesion. The lesions will continue to enlarge as the fungus mycelium grows outward from the edges of the lesion in all directions. Mature lesions will measure 8-10 mm in width and may be circular, elliptical or irregular in outline. Mature lesions will be brown to charcoal gray in color. The lesion stands out as a black lesion against the red background color on cashew fruits. Close inspection of the lesion will reveal small, yellow to orange masses of viscous conidia on the lesion.

Many saprophytic fungi (and bacteria) will invade fruit tissue infected with *Colletotrichum* sp. These microorganisms secrete enzymes, which contribute to the decomposition of fruit tissue and will play the most important role in the development of soft rot symptoms. The watery, black, soft-rot symptom may involve a large portion or all of fruits, especially green pepper, in the intermediate to final stages of decay.

**Control:** Anthracnose is a disease of mature guava, pepper and papaya fruit. The most effective control measure is harvest of guava and papaya fruit at the earliest possible time before full maturity.

Protectant fungicides, such as Benlate or Dithane M-45, applied every 4-6 days during the mid-period of fruit development will provide some control of anthracnose. Allow at least 7 days between last spray and harvest for both of these fungicides.

*Colletotrichum* spp. invade fruit tissues through injuries resulting from insect feeding or ovipositing much more rapidly than directly through the uninjured outer layers of the cells of the fruit. Insect control, especially Mediterranean fruitfly on guava, therefore, is essential to reduce injuries resulting from insects. Bruises from improper handling also provide areas through which the germ tube of the conidia may easily penetrate. Careful handling of the fruit is another method of

control of anthracnose (and fruit rots in general).

The pathogen will produce conidia on diseased fruit that remains on the plant or that falls to the ground. These conidia may be disseminated to healthy fruit where they will germinate to initiate the infection cycle. Early harvest and prompt removal of fallen fruit are recommended procedures for control of anthracnose by elimination of sources of inoculum.



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**Disease:**
**BEAN RUST**

**Host:** Garden beans *(Phaseolus vulgaris)*

**Pathogen:** *Uromyces phaseoli* or *U. appendiculatus*

**Symptoms:** Very small (1 mm), circular, yellow spots will appear on leaves and young pods of beans infected by this fungus. These lesions will enlarge over a 4- to 5-day period to about 2-4 mm in diameter. The chlorotic halo will persist around the lesion, but the center will be "rust" red in color. This is due to the large numbers of red-colored urediospores produced by the pathogen. Old lesions may turn brown to black in color as the leaf cells in the lesions die. Under conditions of heavy infection, premature defoliation can occur.

**Control:** Although this disease frequently is observed in Seychelles, it has not been known to cause losses in production. The greatest threat to production occurs whenever large numbers of lesions develop on many leaves of young plants. Destroying these leaves will eliminate the spores and diminish the amount of disease. Protectant fungicides such as Bravo and Dithane M-22 may be necessary on a 5- to 6-day schedule when early and heavy infection occurs. Five- to seven-day intervals between last spray and harvest are necessary when these fungicides are used.

Some varieties are resistant, but more than 30 specialized races of this pathogen occur. The races present in Seychelles are not known.

**Disease:**
**BROWN LEAF SPOT**

**Host:** Cassava *(Manihot esculenta)*

**Pathogen:** *Cercospora (Cercosporidium) henningsii*

**Symptoms:** The initial symptom of this disease appears as small, irregular, chlorotic lesions on infected leaves. The center of the lesion turns brown as the lesion continues to enlarge over a 4- to 6-day period. The mature lesion will be irregular to circular in outline, 1.2-1.8 mm in diameter, tan to brown in color with a chocolate brown border. A diffuse irregular yellow zone will surround the lesion. Lesions of various stages of development may occur on the leaves. The lesions may be limited by major veins and, consequently, will be somewhat angular in outline. Several lesions may grow together to produce large irregularly shaped areas of dead tissue. Premature defoliation may occur when leaves are severely infected (many lesions per leaf). This disease usually is most severe on the oldest leaves. In general, it does not appear to be sufficiently serious to result in losses of economic importance.

**Disease:**
**CANE BLIGHT**

**Host:** Passion fruit *(Passiflora laurifolia)*

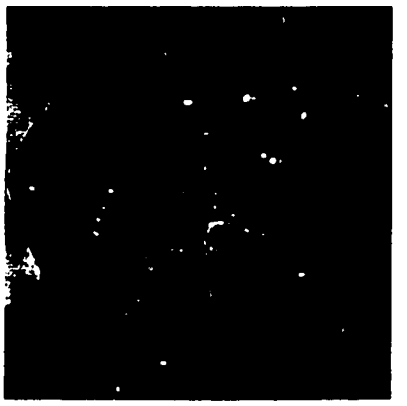
**Pathogen:** *Colletotrichum* sp.; *Botryodiplodia theobromae*

**Symptoms:** The pathogen (or pathogens) which cause this disease enter and develop in the tissues of the vines. The initial symptom is a small, brown, elongate canker or lesion, which will not be noticeable during early stages of development. The leaves that develop between the point of infection and the tip of the individual canes, however, will wilt and turn yellow in color as water and mineral transport is restricted by the developing lesion. The cane lesion will continue to enlarge and will girdle the cane and increase in length along the cane. It will be tan to brown in color and will stand in contrast to the green of the healthy areas of the cane. Masses of spores will be visible as small black pustules on infected areas of the canes. The leaves will die and become dry and brown as the disease progresses.

**Control:** Spores produced on infected canes are carried to healthy canes by air currents or by splashing rain. Consequently, it is necessary to prune away infected canes and destroy by burning or burying. Weekly application of Bravo 500 or Dithane M-45 are fungicides that provide control of this disease.

Characteristics of the soil, such as nutrient levels or water supply, in which passion fruit is grown may influence the development of this disease. In other words, deficiency of some essential mineral or moisture deficit may affect the plant in such a way as to increase its susceptibility to attack by the pathogen. This is referred to as predisposition. Consequently, good cultural, fertilizer and irrigation practices may be important for the control of this disease.

**Disease:**
**CERCOSPORA LEAF SPOT**



**Host:** Pepper *(Capsicum annuum)*

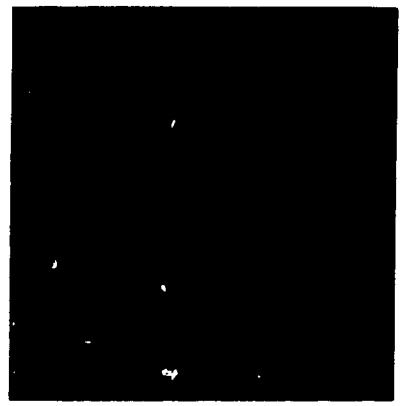
**Pathogen:** *Cercospora capsici*

**Symptoms:** Lesions commence as small, circular, water-soaked, dark-green spots. The centers of the lesions become white to gray in color as leaf cells are killed by the fungus. These necrotic centers are surrounded by a red to dark-brown border. A diffuse chlorotic halo usually surrounds the lesion during late stages of development. Coalescence of lesions may occur whenever heavy infection (large numbers of lesions) develops. Defoliation frequently will occur under these conditions. The necrotic centers of lesions may fall from the lesions, imparting a "shot-hole" appearance to the leaf. Inspection with a hand lens will reveal small, black masses of conidia of the fungus on the lesions.

**Control:** Mycelium of *C. capsici* survives in dead leaf debris in the field. Consequently, sanitation by removal of dead leaves is recommended whenever possible. Certified seed with a protectant fungicide should be used since conidia of the pathogen may be transmitted on the seed. Disease-free seedlings should be used for transplanting.

Conidia are wind-blown or are disseminated by splashing rain or by workers moving from plant to plant in the field. These conidia may then germinate in moisture on the leaf, allowing the germ tubes from the conidia to penetrate the leaf. This sequence of events will start the disease cycle over again. Consequently, cultivating and picking operations should be carried out when the leaves are dry. Protectant fungicides, such as Bravo 500, Dithane M-45, Dithane M-22, or Manzate D, can be applied on a regular schedule as soon as symptoms appear to control this disease.

**Disease:**
**CERCOSPORA LEAF SPOT**



**Host:** Garden beans *(Phaseolus vulgaris)*

**Pathogen:** *Cercospora canescens*

**Symptoms:** Small, yellow, irregular spots develop on leaves infected by *C. canescens*. These lesions will continue to enlarge to become up to 1 cm or so in diameter. Mature lesions will be brown to grey with a dark brown margin; they will be subcircular to irregular in shape and may be limited by the major veins of the leaf, which will give the lesion a slightly angular appearance. Coalescence of several of these lesions may cause sections of the leaf to turn yellow and to fall from the plant prematurely. Infection of the pods may occur, resulting in irregular brown to grey lesions. Stem infection also may occur.

**Control:** *C. canescens* may survive on old bean plant debris remaining in the field after harvest. Destruction of these leaves by tilling into the soil is one method of control. Pod infection may occur, resulting in possible seed dissemination. Use of disease-free seeds, therefore, is another control measure. Dithane M-45 can be applied at regular 5- to 7-day intervals commencing with the first appearance of symptoms, leaving 4 or 5 days between the last application and harvest.

**Disease:**
**CITRUS SCAB**

**Host:** Oranges, lemons, grapefruit *(Citrus* spp.)

**Pathogen:** *Elsinoe fawcettii*

**Symptoms:** Lesions appear on the leaves as small, circular, corky, raised areas. These lesions continue to enlarge and become yellow to orange in color. Numerous lesions on individual leaves result in chlorosis of the leaf and early loss of the leaf from the tree. Similar warty growths also occur on twigs and fruit. Infection on seedlings may result in stunting of the plant.

**Control:** Periodic pruning is a necessary aspect of efficient orchard management. Many branches and limbs with citrus scab will be removed by these routine practices. Limbs or branches with obvious disease lesions should be pruned as soon as the disease is observed. The lesions on these branches will continue to produce spores of the fungus that causes the scab disease after removal from the tree. The spores can be carried by air currents from the prunings to uninfected leaves, fruits or branches where the disease cycle will be initiated over again. Consequently, it is important to destroy these prunings by burning.

Benlate or Difolatan are effective fungicides for control of citrus scab. These are primarily protectant fungicides and must be applied at regular intervals (depending upon the intensity or amount of disease present). Thorough coverage of leaves, fruit and young limbs (new growth) also is essential to maintain control of this disease.

Sanitation practices, such as removal of fallen leaves, will contribute to the control of citrus scab.



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**Disease:**
**CORYNESPORA LEAF SPOT**

**Host:** Cucumbers *(Cucumis sativus)*

**Pathogen:** *Corynespora cassiicola*

**Symptoms:** The symptoms of this disease resemble symptoms that develop as a result of infection by *Cercospora cucurbitae*. *Cercospora cucurbitae*, however, has not been found in association with the lesions on cucumber leaves in the Seychelles.

Small (2 mm), circular, chlorotic leaf lesions are the initial symptoms of this disase. The lesions increase in diameter within a few days, at which time the center of the lesion will be light tan surrounded by a yellow halo. The margin of the center of the lesion may be a light rust-brown color.

The growth of the fungus responsible for cucumber leaf spot is restricted by the veins, resulting in angular necrotic lesions with a square or rectangular outline. These mature lesions will be 4-6 mm square, or 4-6 mm wide by 8-10 mm long. The chlorotic halo may be present around lesions of all sizes and stages of development. Adjacent lesions may merge whenever large numbers of individual infection centers occur on a single leaf. This will result in large, 15-20 mm square (or larger) areas of dead leaf tissue. These areas will become distorted and curled. Individual leaves may be killed.

Heavy disease intensity (large numbers of lesions on large numbers of leaves) will decrease the photosynthetic area of many leaves. Large numbers of these leaves may fall from the plant. Yields and quality will be reduced if this type of disease situation develops early in the growing cycle of the plant.

**Control:** The recommended control measures for this disease involve a combination of practices, such as protection by fungicide sprays and environment control, and eradication by sanitation.

Fungicides, such as Difolatan or Bravo, should be applied regularly at 5- to 8-day intervals at the appearance of first symptoms. Good coverage of all leaves at each spray application is essential to achieve control of this leaf spot disease.

The conidia of the pathogen require free moisture on the plant leaves for infection to occur. Consequently, irrigation water should be applied to the soil surface whenever possible. Irrigation should be accomplished during the early morning so that water on the leaves will evaporate early in the morning. Fungicides should be applied after irrigation to assure good distribution of the fungicide and to reduce the amount of fungicide removed from the leaf by irrigation water applied

after spraying.

Removal of infected leaves is recommended whenever possible. This practice will eliminate conidia, which could serve as inoculum for healthy leaves, and also will improve air circulation, which will hasten drying of the leaves.

Crop debris with infected leaves should be tilled into the soil or removed to eliminate inoculum produced on the diseased leaves.

**Disease:**
**CORYNESPORA LEAF SPOT (BLIGHT)**

**Host:** Tomatoes *(Lycopersicon esculentum)*

**Pathogen:** *Corynespora cassiicola*

**Symptoms:** The characteristic symptom of this disease commences on the lowermost leaves as a 1-2 mm yellow leaf lesion. The center of the lesion becomes chocolate brown within a few days with a persistent chlorotic halo. The mature lesions generally measure 3-6 mm in diameter and will be irregular or angular in outline. Adjacent lesions will coalesce when large numbers of lesions occur on a single leaflet. This infected area will turn brown and dry. Severely infected leaves may fall from the plant prematurely. Lesions will begin to appear on the middle and upper leaves of the plants within 60 days after transplanting. Multiple infections on a single leaf hasten the destruction of these leaves, which become yellow and die prematurely.

*Corynespora cassiicola* also will infect the stems, leaf petioles and fruit peduncles of tomato plants, resulting in dark gray to black, long (2 mm by 4 mm) lesions.

**Control:** Corynespora leaf spot is a common and potentially important leaf disease of tomatoes in the Seychelles. Control of this disease is essential for maximum fruit production.

*Corynespora cassiicola* produces large numbers of conidia on leaf lesions and on old leaf debris left in the field after harvest. These conidia are disseminated to healthy leaves by air currents or by splashing rain. New cycles of infection are initiated when these spores germinate and infect the leaves. Infected leaves should be removed and destroyed to eliminate these sources of spores. Removal or burial of plant debris also is an important control measure.

Early and repeated applications of foliage protectant fungicides are essential to provide good control from the seedling and juvenile stages of plant development through to harvest. Bravo or Difolatan are recommended fungicides. Application should commence within 1 to 2 weeks after transplanting and be continued at 5- to 7-day intervals throughout the growing period of the plants. All leaves and stems should receive complete coverage of fungicide at each spray application.

**Disease:**
**DOWNY MILDEW**

**Host:** Cabbage *(Brassica oleracea* v. *capitata)* and others such as brussel sprouts and cauliflower

**Pathogen:** *Peronospora parasitica*

**Symptoms:** The initial symptom of the downy mildew disease is the appearance of small, irregular to circular, chlorotic lesions on infected leaves. The center of the lesion becomes yellow to yellow-brown in color surrounded by a diffuse area of chlorosis as the lesion continues to develop and enlarge over a 2- to 4-day period. Downy or cottony-appearing, gray-white, spore-bearing structures (sporophores) appear on the underside of the lesion (lower leaf surface) within a day or so of the appearance of the lesion. These structures give the disease the name "downy mildew." The growth of the fungus mycelium in the leaf tissue is restricted by the major veins. Consequently, the mature lesions are somewhat angular in outline. Coalescence of several lesions will result in large, irregular patches of dead leaf tissue. Yield and quality of cabbage (or other *Brassica* spp.) will be reduced whenever large numbers of leaves are severely infected.

Large areas of young leaves will become dull green and "water soaked" in appearance when infected by *Peronospora parasitica.* These areas will wilt and become yellow in color. The gray-white, spore-bearing structures will impart a "downy" appearance to the underside of these infected leaves. These leaves will collapse and die within 4 to 6 days of the appearance of symptoms.

**Control:** The fungus structures (sporophores), which give the lower lesion surface the downy appearance, produce immense numbers of spores, which are air-borne to healthy leaves on plants within a radius of several miles. Removal and destruction of these leaves is an important method of sanitation for control of this disease. The spores of the fungus require free moisture on the leaf in order to germinate and for the germ tube to penetrate the leaf. Consequently, some control of the disease may be possible by limiting irrigation to early morning hours by surface methods. Care should be exercised not to crowd seedlings when possible, since dense populations create an atmosphere with high moisture around the plants. Only disease-free seedlings should be used for transplanting. The protectant fungicide Bravo 500 can be applied to mature plants at 4- to 6-day intervals. This fungicide should *not* be used on seedling cabbage plants. Dithane M-22, Manzate D or Ridomil also may be employed to control downy mildew of cabbage.



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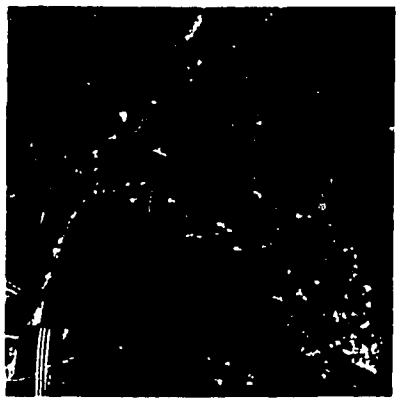
About 7 days should remain between the last spray and harvest when these fungicides are used.

**Disease:**
**DOWNY MILDEW**



**Hosts:** Watermelon *(Citrullus vulgaris)*, melon *(Cucumis melo)*, cucumber *(C. sativus)*, pumpkin or squash *(Cucurbita maxima)*, calabash *(Lagenaria siceraria)*, bittergourd *(Momordica charantia)*, snakegourd *(Tricosanthes anguina)*

**Pathogen:** *Pseudoperonospora cubensis*

**Symptoms:** The fungus that causes downy mildew is spread from infected leaves to healthy leaves by air-borne spores. The spore germinates during the early morning hours when abundant moisture is present on the leaf to produce another type of small, motile spore referred to as a zoospore. The zoospore germinates to produce a thread-like germ tube, which enters the leaf through stomatal openings on the leaf. The fungus then grows between the green cells of the leaf, destroying the cells as growth of the pathogen continues.

The effect of the invading fungus on the leaf cells results in a small, irregularly shaped, chlorotic lesion on the upper leaf surface a few days after infection by the germ tube of the zoospore. The areas of the underside of the leaf beneath the chlorotic lesions develop a gray-white to blue-gray, downy (or cottony) appearance a day or two after the chlorotic lesion develops. This downy material is composed of the asexual reproductive structures of the fungus and indicates that new crops of spores are being produced. These spores are then air-borne to healthy leaves where the infection process begins again.

The original, small, chlorotic lesions will continue to enlarge to form irregular areas of chlorosis 1.5-2.0 cm in diameter. The centers of the mature lesion will become gray to brown in color as the leaf cells die. When infection is severe, several of these necrotic lesions may coalesce to form large irregular patches of dead leaf tissue. Severely infected leaves may wilt, turn yellow and die. The loss of leaves early in vine development prevents full fruit formation, and losses will be serious.

**Control:** Several pathogenic biotypes of the downy mildew pathogen are known. In other words, subspecies of the pathogen that attacks cucumbers may not attack watermelons, etc. Some subspecies which attack one variety of cucumbers, in addition, may not attack other varieties. The resistance of different varieties of crops of Seychelles attacked by the downy mildew pathogen is not known at this time, and consequently, control by resistant varieties is not currently possible.

Bravo 500, Dithane M-22, Dithane M-45, Ridomil or Manzate 200 are

protectant fungicides recommended for control of downy mildew. They should be applied at time of appearance of the first symptoms of disease and continued at 5- to 7-day intervals. A 5-day waiting period between final spray and harvest should be allowed when Dithane or Manzate are used.

**Disease:**
**EARLY BLIGHT**

**Host:** Tomato *(Lycopersicon esculentum)*

**Pathogen:** *Alternaria solani*

**Symptoms:** Symptom development commences on the leaves as minute chlorotic spots. These lesions will continue to enlarge to 8-12 mm in diameter as the mycelium of the fungus grows between the cells of the infected leaf. The center of the lesion becomes gray to brown in color as the leaf cells die. Concentric rings of various shades of gray to brown tissue encircle the center of the lesion, reflecting the progressive outward growth of the pathogen. A chlorotic halo encloses the lesion throughout the various stages of development. These concentric rings give the lesion a "target-spot" appearance. The general outline of the lesion is circular, but shallow lobes may develop to present a slightly irregular shape. The mature lesion extends from the upper to the lower leaf surface. Several lesions may coalesce to form one to several large lesions. Large amounts of leaf surface are destroyed under this condition, and the leaf may fall from the plant.

Infection also may occur on leaf petioles resulting in small brown to black lesions. Leaves with petiole infection generally are lost from the plant.

Brown to black lesions result from infection of the fruit. Infected areas of the fruit become leathery in appearance and are covered by a black felt of sporulating mycelium.

Losses resulting from the activities of *A. solani* are both indirect and direct. Indirect loss comes about as a result of loss of photosynthetic area of the leaf by individual lesions or by loss of entire leaves. *Alternaria solani* is responsible for direct losses by destruction of fruit and by causing fruit to drop prematurely through peduncle (fruit stem) infection. The amount of loss will depend upon the period during plant development in which infection develops, the numbers of plants infected and the severity (intensity) of the disease.

**Control:** *Alternaria solani* can survive as mycelium or as conidia in or on tomato leaf and stem debris remaining in the field after harvest. It is important, consequently, to remove infected host tissue or to bury this debris after harvest.

Seeds from diseased fruit may be contaminated with spores or mycelium of the pathogen. Certified seed is highly recommended since this seed generally is pathogen-free, is of known pedigree, and usually has been treated with a fungicide to control *A. solani* and other seed-

borne fungi.

The conidia of *A. solani* are air-borne and are deposited on leaves, stems and fruit, where infection occurs. Rain or irrigation water also may carry conidia from active lesions to healthy tissue. Protectant fungicides, such as Bravo, may be applied at first symptoms of disease, and continued at 5- to 7-day intervals through harvest for control of the disease. Dithane M-22, Dithane M-45 or Manzate 200 are other protectant fungicides that provide control of early blight. A 5-day waiting period between last spray and harvest should be allowed for these fungicides. Benlate (50W benomyl) also is recommended for early blight control.



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**Disease:**
**FUSARIUM WILT**

**Host:** Tomatoes *(Lycopersicon esculentum)*

**Pathogen:** *Fusarium oxysporum* f. sp. *lycopersici*

**Symptoms:** The fungus responsible for this disease survives on tomato plant debris in the soil as mycelium or as conidia. The mycelium of the pathogen penetrates and grows into water and nutrient-conducting tissues of the vascular network of the root and lower stem, thus restricting the upward movement of water and minerals. The initial symptoms are a stunting of young plants and a general yellowing of the lower leaves. These leaves will die and may drop from the plant as symptoms progress. The leaves on one side of the plant may be more seriously affected than those on the opposite side. Leaves on the middle and upper part of diseased plants will become chlorotic and die with time. Ultimately the plant will die.

Enzymes produced by the pathogen decompose water-conducting cells of the vascular system, resulting in a chocolate brown discoloration. This is evident in a cross section of the stem as a discolored ring of tissue outside of the pith and just inside of the outer layer (cortex) of the stem.

The wilt symptom usually is not a major symptom on leaves of infected plants. A serious wilt is generally more typical of plants with bacterial wilt. A cross section of the lower stem of plants with bacterial wilt reveals a general dark, soft decomposition of the interior (pith) of the stem.

Fruit will not mature on plants infected at an early stage. Some fruit may mature on late-infected plants or in cases where the disease is not serious. Yields will be reduced, and fruit maturation terminated as the disease continues to develop on plants of all ages.

**Control:** *Fusarium oxysporum* attacks many species of plants. The Fusarium identified in Seychelles, however, probably attacks only tomatoes. Planting other vegetables on land where Fusarium wilt is a problem is one method of control. The fungus is capable of surviving for long periods of time in the soil. Consequently, alternate crops will need to be grown for two or three years before tomatoes are planted.

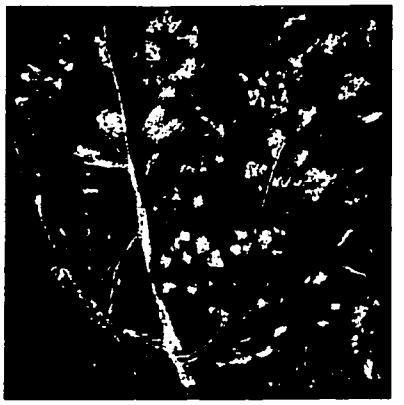
The fungus pathogen *(Fusarium oxysporum)* is spread by running water, soil movement or on transplants. Soil on cultivating tools used in areas of known contamination with Fusarium should not be moved into Fusarium-free areas. Only disease-free transplants should be used.

Control by application of chemicals is feasible, but is expensive,

difficult to carry out, and many of the potential fungicides are dangerous to handle. In addition, data concerning the most effective fungicides is not available for Seychelles conditions. Consequently, this method of control is not generally recommended at this time.

Many varieties are resistant to the Fusarium pathogen, but complete information on this aspect of control is not currently available for the Seychelles.

**Disease:**
**LEAF MOLD**



**Host:** Tomatoes *(Lycopersicon esculentum)*

**Pathogen:** *Cladosporium fulvum*

**Symptoms:** The first symptoms of leaf mold are small, irregular, yellow areas without distinct margins or borders. The yellow areas will increase in size within a few days to measure 5-8 mm in diameter. The leaf tissue surrounding the yellow areas will be a normal green color at this stage in symptom development. Individual lesions will merge together as the fungus continues to grow into healthy tissue around the original lesion. A large portion of the leaf will become yellow and begin to turn brown as large areas of leaf tissue die. The underside of infected leaves will develop a fuzzy, gray-brown color a day or two after the chlorosis symptom develops. This discoloration is due to the formation of large numbers of conidia (spores) and conidiophores (the specialized branches of the fungus that grow out from the leaf and produce the conidia) by the fungus pathogen.

The first symptoms of leaf mold always appear on the oldest (lowest) leaves of the plant. Within a few days, however, symptoms begin to develop on leaves mid-way on the plant and will continue to develop on additional leaves with time. Consequently, yields from plants with heavy infection early or mid-way in plant growth will be reduced. Disease development during late stages in plant growth will have little or no effect on yields or fruit quality.

**Control:** *Cladosporium fulvum* survives as mycelium in infected leaves that remain on the soil after harvest. This mycelium will produce conidia, which will serve as inoculum to initiate new cycles of disease. One important method of control of this disease, consequently, is sanitation whereby old leaves are removed and destroyed or worked into the soil.

Spores (conidia) are produced in large numbers on infected leaves and are windborne to healthy leaves. The germ tube from these conidia penetrates the leaf and commences the disease cycle over again. Removal and destruction of these infected leaves is another important control measure. The application of Benlate at 6- to 7-day intervals commencing at first symptoms also is recommended. It is important to achieve good coverage of all leaves at each application.

**Disease:**
**PARACERCOSPORA LEAF SPOT**

**Host:** Egg Plant *(Solanum melongena)*

**Pathogen:** *Paracercospora egenula*

**Symptoms:** The initial symptom of this disease is a 1-2 mm circular, yellow lesion. As the lesion enlarges, the center will turn tan to brown in color as the leaf cells are killed by the pathogen. The necrotic center will be surrounded by a yellow halo, which will persist as the lesion develops. The mature lesion will measure about 7-10 mm in diameter. Individual lesions will coalesce when large numbers of lesions develop adjacent to one another on the same leaf. These large diseased areas will lose water rapidly, become dry and dark brown to gray in color, and will buckle and curl. Leaves with this high level of infection will drop from the plant prematurely.

**Control:** Paracercospora leaf spot has been identified at several locations on Mahe, but is not known to result in economic losses in egg plant production. Infection of large numbers of leaves of young plants could result in loss of leaves sufficient to reduce yields. In these cases Dithane M-45 or Brave applied 2-4 times at 5- to 7-day intervals should provide control. The pathogen produces masses of conidia on the leaf lesions. These conidia are carried by air currents to young uninfected plants where the disease cycle commences all over again. Consequently, it is important to remove and destroy infected leaves whenever possible.

**Disease:**
**POWDERY MILDEW**

**Hosts:** Cucumber *(Cucumis sativus)*, melons *(Cucumis spp)*, watermelons *(Citrullus vulgaris)*, squash *(Cucurbit spp)*

**Pathogen:** *Erysiphe cichoracearum*

**Symptoms:** The mycelium of the fungus *(E. cichoracearum)* causing powdery mildew develops superficially on the leaves of the host. This mycelium, together with the large numbers of chains of spores (conidia) produced on this mycelium, impart a white, granular, mealy or powdery appearance to infected areas of the leaf. The white, powdery areas enlarge as the pathogen continues its development on the leaf. The numbers of diseased areas also increase as new infection centers originate. In cases of severe infection, a large portion of many of the leaves of infected plants will show signs of the presence of the pathogen. The common name "powdery mildew" is given to this disease because of the appearance of the fungus mycelium and conidia.

Small, black, globose fungus structures referred to as cleistothecia may form on the mycelium within 6 to 10 (or more) days after the appearance of the white, powdery mycelium and conidia. The cleistothecia are just visible to the naked eye and are difficult to see without a hand lens. Another type of spore, the ascospore, is produced inside of the cleistothecium.

Infected areas of leaves will develop irregular, interveinal, chlorotic lesions, which will ultimately die and become gray-brown to brown in color. Severe infection of young leaves results in leaves that are stunted, curled and deformed. Fruit from infected vines will be small and of poor quality. The effect on yield will depend upon time of infection during plant development, number of leaves infected and severity of infection.

**Control:** Benlate, Milcurb, Bayleton and Karathane are fungicides that are effective for the control of powdery mildew of cucurbits. These fungicides should be applied at the first signs of disease and every 5 to 7 days afterwards. Good coverage of all leaves at each application is important to achieve good control.

Resistance to powdery mildew is available for several crops. The resistance of local varieties is not known at this time.

**Disease:**
**POWDERY MILDEW**

**Host:** Papaya *(Carica papaya)*

**Pathogen:** *Ovulariopsis papayae*

**Symptoms:** The initial indication of this disease is the appearance of small irregularly shaped patches of the white to gray, powdery mycelium on the lower surface of leaves four or five (from the top of the plant). The white mycelium of the pathogen will continue to expand slightly over a 2- or 3-day period. The first symptoms occur at this time as chlorotic areas of leaf tissue on the upper leaf surface opposite from the white patches of mycelium on the lower leaf surface. As the leaves continue to age, the lesions will increase in numbers and in size. The mature lesion generally measures 1 cm or less in diameter and will be brown to brown-gray in the center as leaf cells are killed by the fungus. Several other fungi may invade these lesions and contribute to death and discoloration of the mature lesions. Some chlorotic tissue persists around the margin of the lesion.

**Control:** As a rule, powdery mildew is not an important disease on papaya in Seychelles. Benlate can be applied with a 7-day waiting period between the last spray and harvest of the fruit.

**Disease:**
**SCLEROTIUM STEM BLIGHT**

**Hosts:** Pole beans *(Phaseolus vulgaris)*, Chili pepper *(Capsicum annuum)*

**Pathogen:** *Sclerotium rolfsii*

**Symptoms:** The first symptoms on plants attacked by *S. rolfsii* are yellowing and wilting of the lower leaves of infected plants. These leaves turn brown and dry and may fall from the plant. Mid-plant leaves will become chlorotic, and the plant itself will be stunted as growth rate diminishes. Plants that become infected during seedling or juvenile growth stages generally will die before fruit maturity. Plants infected in later stages of development will produce less fruit than plants infected early in growth even though they may not be killed by the pathogen.

The primary symptoms of disease on the stem are less obvious than the secondary symptoms already described. The pathogen responsible for Sclerotium stem blight invades the stem at or just below soil level, and grows into and kills the outer stem tissues. This activity results in an elongate, brown, sunken lesion, which continues to enlarge and girdle the stem. This activity of the pathogen restricts upward movement (translocation) of water and mineral nutrients to the leaves. The leaves consequently wilt, turn yellow, then brown and die.

Other diagnostic features of this disease are the signs or indications of the presence of the fungus responsible for the disease. The mycelium of *S. rolfsii* will be seen as white, cottony strands growing over the surface of the lower stem. As development continues, small white knots of mycelium appear. These structures (the sclerotia) will continue to enlarge and will turn tan, then brown, in color and will measure 2-3 mm in diameter. Fruit near the soil surface may become infected by *S. rolfsii*. These fruits will develop soft rot symptoms and ultimately will be covered with the white, cobweb-like strands of mycelium and the small, hard, brown sclerotia.

**Control:** Sclerotium stem blight has been reported only on chili peppers and on pole beans to date in the Seychelles. Consequently, crops other than these should be grown in soil known to be contaminated with the pathogen. *S. rolfsii* has a very wide host range in many parts of the world and is known to infect tobacco, tomatoes, cucumbers, watermelon, sweet potato, eggplant and many other host plants. It is very probable that other hosts will be reported for this pathogen in the Seychelles if control measures are not carried out.

The sclerotia are capable of long-term survival in the soil. Consequently, long rotations away from susceptible crops may be necessary



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once soil becomes heavily contaminated with these fungus structures.

The sclerotia may persist on the host debris, or they may be separated from the debris and become components of the soil mycoflora. These sclerotia are readily disseminated from areas of infested soil to pathogen-free areas on cultivating tools, or in irrigation or rain water. It is imperative that every precaution be taken to prevent this dissemination from contaminated to uncontaminated areas.

Fumigation of small areas of soil contaminated with *S. rolfsii* is another method of control. The soil in the area to be treated must be properly tilled to permit good penetration of the fumes of the methyl bromide fumigant. The soil should be fairly dry, not wet. The soil to be treated must then be covered with a gas-proof sheet of plastic with the edges sealed. Methyl bromide is then released under the plastic from 680 g containers at a rate of about 680 g per 14 sq. m. Methyl bromide is extremely toxic and is a dangerous pesticide. Treatment should be administered only by trained, experienced personnel.

Supplemental fertilization with calcium nitrate (15.5% N) at 11 g per sq. m. mixed into the soil at time of transplanting or planting has been found to afford some control of *S. rolfsii.* Practices which facilitate decomposition of old host debris in the soil, such as thorough tillage of soil after harvest, also will be effective in control of this disease.

**Disease:**
**WHITE RUST**

**Hosts:** Chinese cabbage *(Brassica pekinesis)* and other *Brassica* spp.

**Pathogen:** *Albugo candida*

**Symptoms:** A yellow, local lesion is the earliest and most noticeable symptom of this disease. The lesion does not enlarge appreciably, but the center will become gray to brown in color with time. Several lesions may merge to result in large areas of dead leaf tissue. The fungus produces large numbers of spores on the lesions on the underside of the leaf. The lesion then becomes mealy or powdery in appearance and white in color, hence the name "white rust." Infected stems or flower parts are distorted and enlarged or swollen. The white, powdery spores may be produced along the entire shoot axis.

**Control:** White rust has not been observed frequently in Seychelles and does not appear to result in serious crop losses during most years. Spraying with Dithane M-22 or Manzate D at regular intervals, commencing with observation of first symptoms, is the most practical method of control. Destruction of infected plant material is another method of control to be practiced if this disease becomes a problem.



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**Disease:**
**BANANA ROOT ROT, BLACKHEAD, or BLACKHEAD TOPPLING DISEASE**

**Host:** Banana *(Musa* spp.)

**Pathogen:** *Radopholus similis* (burrowing nematode)

**Symptoms:** Many different races of *Radopholus similis* have been identified on more than 250 hosts. These races are host specific and, in general, races that attack one crop will attack very few (or no) other crops. The race that attacks bananas will not attack citrus. The race that attacks citrus, however, does attack bananas.

The nematode larvae hatch from eggs in the soil and move to young banana roots. The nematode then penetrates into the root where they tunnel and feed on the cortex cells of the root. The feeding activities destroy many of the root cells, leaving brown to black lesions in the infected roots. Nematodes also may enter the rhizome, resulting in the development of typical lesions. Fungi and bacteria that invade these nematode-created tunnels result in further destruction of the roots and rhizomes.

*Fusarium oxysporum* f. sp. *cubensis* causes Panama disease or Fusarium wilt of bananas. Fusarium wilt will be much more severe in plants invaded by *R. similis,* since *F. oxysporum* will invade banana roots more readily following infection by the nematode.

Secondary symptoms appear in the leaves and stems as the effect of nematode feeding activities becomes more pronounced in the roots. Leaves will become yellow and will drop prematurely. The plant will be stunted and may topple over in high winds when the effects of the nematodes are severe.

Nematode feeding impairs the uptake of water from the soil and, consequently, infected plants will be seriously affected by soil water deficits. Fruit quantity and quality will be lowered as a result of infection by the burrowing nematode.

**Control:** Infected rhizomes should be removed from the soil. Soil with diseased bananas should be planted with other crops for at least one year since *R. similis* can survive in the soil without the banana host for only short time periods. Planting bananas in rotation with sweet potatoes, or vice-versa, is not recommended since there is some evidence indicating that the banana race of *R. similis* may attack sweet potatoes. Rhizome sections used for planting should be nematode-free in order to avoid introducing the nematode to new areas and to assure development of a nematode-free rhizome for the new plant. Immersion of banana sets in water at 55°C for 20 minutes will kill the nematodes. Nematicides may be effective as soil treatments if the nematode is not protected within the rhizome.



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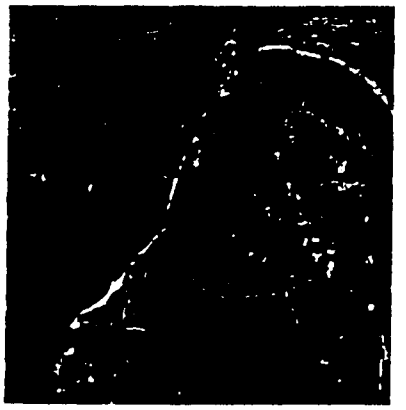
**Disease:**
**ROOT-KNOT**



**Hosts:** Tomatoes, cucumbers, tobacco, melons, eggplant, peppers, papaya, okra

**Pathogen:** *Meloidogyne incognita** and *M. javanica***

**Symptoms:** The damage caused by the feeding activities of nematodes seriously impairs the efficiency of diseased roots. Consequently, the uptake of water from the soil and the translocation of water from the roots to the upper portion of the plant is restricted in direct proportion to the damage of the roots by the parasite. Nutrients essential for normal plant growth, development and reproduction are taken up by the roots in solution from the soil. The detrimental feeding activities of nematodes on the roots, therefore, restricts the concentrations of nutrients essential for plant growth.

The reduction in the efficiency of absorption of water and nutrients by the feeding activities of nematodes on the roots results in the development of secondary symptoms (those which appear in tissues or organs of the host at a distance from the activities of the pathogen) on the upper portion of the host. The initial symptom is a wilt of the lower leaves as the water supply from the roots is diminished by the activities of the root-knot pathogen. The wilt symptom will occur earlier in the life of an infected plant and will be more serious under situations of low moisture in the soil. Symptoms also will occur earlier and be more severe during periods of elevated temperatures, which increase transpiration (water loss from leaves through stomates) rates from the leaves. Wilt symptoms will become more serious and will afflict more leaves as root-knot nematode feeding activities increase.

Chlorosis (a general or local yellow discoloration) will develop on leaves of plants with nematode-infected roots. This yellowing will commence on the lower leaves and will gradually appear on additional leaves as impairment of root function by nematodes becomes more severe. The lower leaves will become brown and die at about the time the middle leaves become chlorotic. The leaves of infected plants will be smaller than normal.

Plants with nematode-infected roots will be stunted in size and unthrifty in appearance. The severity of these symptoms will be greater if the roots are attacked by large populations of nematodes in the early stages of plant growth than if attacked by fewer nematodes at a later

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* Identified from tomatoes on Mahe and cucumber and eggplant from Praslin.
** Identified from papaya from Praslin.

stage of growth. Little or no yield loss will occur from infection by small populations early in plant growth or from large populations late in plant growth.

Infection early in plant growth, or infection by large numbers at mid-growth stages, will prohibit maximum shoot development and flower formation. Fruit that is set on these plants will not reach maximum potential size, and yields will be reduced.

The feeding activities of root-knot nematodes also result in primary symptoms on the roots. Primary symptoms are those that develop as a direct result of the activities of the pathogen. The primary symptom of root-knot nematode infection is the irregularly shaped gall that forms on the roots of infected plants. They may be small, 3-6 mm galls on small lateral roots, or they may be the very large galls, which involve a large portion of some of the larger roots of infected plants. In the latter case, the roots will be distorted and misshapen in appearance. In addition, these severely infected roots will be discolored internally and will have few lateral feeder roots.

**Control:** Root-knot nematodes pose serious problems wherever they occur on sandy soils in Seychelles. They are of only limited importance on the red-earth soils. At present several varieties of tomatoes (such as UHN-52 and UHN-69) have good resistance and should be planted whenever root-knot nematodes are a problem for tomato production on sandy soils.

No resistant varieties are available for most of the vegetable crops grown in Seychelles. Consequently, other methods of control will be necessary. Nemacur (10% granular) nematicide can be employed at a rate of 10-20 gm per sq m (about 6.3 gm per plant) by broadcasting and mixing into the soil just prior to planting. Nemacur is a poisonous chemical and should be used with gloves, protective clothing, safety glasses and a respirator. It is recommended that mixing operations be accomplished with implements, rather than by hand, when Nemacur is applied to planting holes.

The root-knot nematode survives in the soil as eggs in the roots of old crop debris. Consequently, removal and destruction of old root systems when crops are harvested is an essential aspect of control. Thorough working of the soil to mix old, remaining root debris into the soil is another method of cultural control.

Root-knot nematodes are disseminated as eggs or larvae from place to place in soil on implements, in running water and on transplants. Contamination of new crop areas can be kept free of nematodes by using disease-free transplants, controlling the movement of irrigation water whenever possible, and using clean implements for land preparation and cultivation.

**Disease:**
**AFRICAN CASSAVA MOSAIC**

**Host:** Cassava *(Manihot esculenta)*

**Pathogen:** African cassava mosaic virus

African cassava mosaic disease is present in many cassava-growing areas of Africa and Asia and is the most important disease of cassava in the Seychelles. The pathogen causing the African cassava mosaic disease described here recently has been shown to be caused by a virus previously known as cassava latent virus. It is transmitted by the white fly *Bemisia tabaci.*

**Symptoms:** Leaves of infected plants develop a typical mosaic symptom characterized by alternating, irregularly shaped patches and bands of various shades of yellow and green color. The discoloration may involve most or all leaves on a plant, or the symptoms may be present only on certain leaves. The entire infected leaf may be discolored, or the symptoms may be localized at the base of the leaves. The symptoms generally become more severe with time. The leaves of some varieties develop severe symptoms during early stages of growth. Leaves produced by these varieties during intermediate and late growth stages, however, may not develop symptoms. In other words, a variety that may show severe symptoms during early development stages may be almost without symptoms at maturity. The pathogen causing this cassava mosaic disease may interfere with normal leaf development. Consequently, the leaves may develop various degrees of distortion and curling. This symptom is evident by leaves that are very narrow in comparison to their length or that may manifest a downward curling. Infected plants may be severely stunted and produce very low yields of inferior tubers.

**Control:** One of the most important means of transmission of the pathogen causing the cassava mosaic disease is through infected stem pieces used for planting. Consequently, only stem pieces from symptomless, vigorous plants should be used for planting. Infected plants should be rogued from the field at the first indication of disease in order to prevent spread of the pathogen to healthy plants. Many resistant varieties are available. These should be grown in plots where the disease is a problem. The pathogen also is known to be transmitted by white flies. Clean cultivation is important to prevent the increase in the population of white flies in cassava plantings.

**Disease:**
**CORN MOSAIC**

**Host:** Corn *(Zea mays)*

**Pathogen:** Unknown

Although the pathogen responsible for this disease is not known, the symptoms are identical to symptoms that develop on corn infected with several mosaic viruses. In addition, sugarcane in a field adjacent to the diseased corn manifested symptoms typical of mosaic virus infection. Sugarcane mosaic viruses are serologically similar to some corn viruses, and cross infection can occur. Most of the mosaic viruses that infect corn are either not seed transmitted or are transmitted very inefficiently in seed. Sugarcane mosaic viruses can be transmitted in cane sections. This also may be true of corn mosaic viruses that infect sugarcane.

**Symptoms:** The mosaic viruses of corn are generally transmitted from plant to plant by aphids or, in some diseases, by leafhoppers. These insects feed on plants in a random pattern and, consequently, symptoms tend to develop on plants at random in the field. The outstanding symptom of this disease is a series of elongate, yellowish to yellow-green streaks that develop between the veins of infected leaves. These alternating bands of various shades of yellows and greens give the leaf the typical mosaic symptom. Infection at an early stage of plant development may result in dwarfing of the plants.

Yield reduction depends upon the total number of diseased plants and the severity of infection. Ears on severely infected plants may produce relatively few kernels, resulting in serious losses.

**Control:** There is no effective control for this disease at this time.

**Disease:**
**CUCUMBER MOSAIC**

**Hosts:** Green Pepper *(Capsicum annuum)*

**Pathogen:** Cucumber mosaic virus (CMV)

**Symptoms:** Leaves of plants infected with CMV develop typical mosaic symptoms of alternating or mixed irregular patches of various shades of yellow and green colors. The disease becomes more severe with time from original infection and is especially severe when infection occurs on young plants. Severe infection results in development of a "strap-leaf" symptom in which leaves are longer and narrower than healthy leaves. Leaves also may be curled or buckled and frequently will be dwarfed in size. Growth processes may be arrested if infection occurs early in the development of the plant, and stunting of the plant will occur. Yields from diseased plants are reduced since fruit set is diminished; fruits that do set are smaller in size than fruit from healthy plants.

**Control:** CMV is aphid-transmitted. Consequently, good insect control is a method of control of the disease. Many chili and green pepper plants in most areas surveyed on Mahe and Praslin have been found to harbor this virus. Elimination of infected plants, therefore, is another method of control. Many weeds serve as hosts for CMV. The virus can be transmitted from infected weeds to cultivated plants. Good weed control practices are essential for control of CMV.

CMV also is transmitted from plant to plant by mechanical means, such as persons or implements. Virus particles picked up in the course of working with infected plants are transferred to healthy plants, resulting in disease on these plants.

**Disease:**
**WATERMELON MOSAIC**

**Hosts:** Watermelon, cucumbers, squash, melons, pumpkins

**Pathogen:** Watermelon mosaic virus

**Symptoms:** Leaves of plants infected with watermelon mosaic virus develop alternating bands or patches of various shades of yellow and green colors. In cases of severe infection, the leaves will be dwarfed and buckled. They also may develop a "strap-leaf" symptom in which the leaves will be longer and narrower than normal. The mosaic pattern of these leaves will appear as elongate streaks of yellow interspersed with various shades of green. Infection during seedling or juvenile growth stages results in stunted plants. Fruit set of infected plants generally is poor; fruit that is set will be smaller in size and lower in quality than fruit from healthy plants.

**Control:** Some varieties of the various crops which serve as hosts for watermelon mosaic virus have some resistance to the virus. Extension agents or plant scientists at GAC should be consulted regarding the varieties with highest levels of resistance.

Watermelon mosaic virus is transmitted by plant lice (aphids). The aphids probe into the vascular system of the leaves of infected plants and, in the process of obtaining the sap of the plant, will contaminate their mouthparts with virus particles. These aphids will then fly to healthy plants and, in the process of feeding, introduce the virus into the leaf of the healthy plant. Another method of control, therefore, is through the use of insecticides for aphid control.

Cucurbit plants that have passed the period of maximum fruit production should be removed from the field since insects with virus-contaminated mouthparts will move from these old plants to young, uninfected plants.

**Disease:**
**TOMATO JAUNE DISEASE**

**Host:** Tomatoes *(Lycopersicon esculentum)*

**Pathogen:** Unknown

Tomato jaune (or yellow) disease is one of the most widespread and one of the economically most important diseases of tomatoes in Seychelles. A disease of tomatoes with identical symptoms has been described in several areas in Africa. Consequently, the descriptive term "jaune" is being used to identify the disease in Seychelles, rather than coining a new term.

The cause of the disease is not known. Reports from Nigeria indicate that white flies transmit the pathogen of tomato jaune disease. Attempts to transmit a causal agent by insects or by sap have not been successful in Seychelles. The distribution patterns of diseased plants in plots of tomatoes, the way in which symptoms develop, and the symptoms displayed by diseased plants suggest that the disease is probably caused by a virus or a mycoplasma.

**Symptoms:** Interveinal chlorosis of infected leaves is the most obvious and the most frequently occurring symptom. The chlorosis varies through all shades of light green to yellow on different leaves. The veins remain green. There is no predictable pattern of the development of the chlorosis; leaves on some lateral branches may develop the symptom, whereupon leaves on other branches may remain symptomless. A large percent of the leaves of one plant may manifest symptoms with adjacent plants remaining symptomless.

Stunt of leaves is another common symptom and generally is most pronounced on young leaves when infection occurs early in host development. A downward curling or cupping (epinasty) of infected leaves also occurs.

Plants that become infected during the first two or three weeks after transplanting may be dwarfed and, in cases of severe infection, will not branch.

Fewer flowers form on infected plants than on healthy plants. Some of the flowers that do form do not produce fruit, and the fruits produced on these plants are smaller than fruit from symptomless plants.

**Control:** There is no effective control for this disease at this time.

**Disease:**
**BLOSSOM END ROT**

**Host:** Tomatoes *(Lycopersicon esculentum)*

**Cause:** Calcium deficiency

**Symptoms:** Blossom end rot is a nutrient-deficiency disease of maturing and mature tomato fruits. The initial symptom is a small, dark-green, water-soaked area that develops around the lower end (blossom end) of tomato fruits. As the lesion continues to enlarge, the center becomes gray-brown to black. Ultimately the entire lesion is black in color, leathery, may be somewhat sunken, and will involve large areas of the fruit.

Fruit cell development does not proceed normally in tomato plants deficient in calcium. The cells of the blossom end of tomato fruits are slightly lower in calcium than other cells. Consequently, these cells are the ones that develop deficiency symptoms. High levels of nitrogen in the soil; imbalance of several nutrients, including nitrogen; rapidly fluctuating soil moisture; or conditions which result in rapid loss of water are all factors that determine the onset and severity of blossom end rot. Many fungi and bacteria invade fruit cells in which blossom end rot symptoms develop. These micro-organisms intensify the blossom end rot symptom.

**Control:** Establishing optimum balances between nutrient types (especially nitrogen and calcium) and amounts and soil moisture is the key to control of blossom end rot. Each local soil will vary in the way in which these soil characteristics must be adjusted for this balance. Consequently, most effective control will depend upon soil test results as a guide to proper fertilization and individual judgment concerning timing and amount of irrigation.

Calcium nitrate or calcium chloride at 6 g/1 can be applied as a spray to foliage at time of earliest symptom development to obtain some control of this disease.

**Disease:**
**IRON DEFICIENCY**

**Host:** Sweet potatoes *(Ipomoea batatas)*

**Cause:** Iron deficiency

**Symptoms:** Iron is an essential micronutrient (one required in small amounts) for several chemical reactions in plant metabolism. Chlorophyll production is diminished, and previously synthesized chlorophyll may be destroyed in iron-deficient plants. Consequently, an interveinal chlorosis or general yellowing develops in leaves of iron-deficient plants. This symptom is usually observed as local areas or patches of yellow plants in fields of sweet potatoes suffering the effects of iron deficiency. Additional plants will manifest iron deficiency symptoms with time in most soils characterized by low levels of iron.

Symptoms of iron deficiency become progressively more severe on individual plants. Small areas of the interveinal chlorosis become brown in color. These areas will continue to enlarge in cases of severe deficiency until large portions of iron-deficient leaves are brown in color. Plants will be stunted in size if iron deficiency develops early in the life of the plant. Yields from these plants will be seriously reduced.

**Control:** Iron deficiency can be controlled by soil management practices on many sandy soils. Animal manure and compost of plant origin contain iron, which is released into the soil as the organic residues decompose. The use of recommended quantities (ca. 15T/ha) of high quality compost is important to prevent iron deficiency. The availability of iron (solubility) is maximum when the pH of the soil is below 5.8. The pH of alkaline (high pH) soils should be adjusted with acid-forming fertilizers such as ammonium sulfate. The amounts of fertilizers to be applied to any given soil is best accomplished subsequent to a soil test and consultation with extension personnel.

The addition of iron-containing fertilizer, such as ferrous sulfate, may be recommended for maximum production in soils known to be low in iron. Most of the coastal sand soils in the Seychelles are very low in iron. Approximately 40 kg/ha of ferrous sulfate is a general recommendation for these soils. The exact amount to be applied will depend upon the amount of iron in the soils as determined by soil test or by the development of symptoms of iron deficiency.

Iron deficiency can be remedied by the application of soluble forms of iron to plant foliage. Fetrilon or Fetrilon Combi (containing both iron and manganese) can be applied as foliar sprays at 1.8 kg of the chemical in 380 liters of water per ha. Approximately 5.3 g per liter can be applied to

smaller areas. Ferrous sulfate also can be applied as a foliage spray at 11 kg/ha. Use 9.2 g/liter of ferrous sulfate for smaller areas with iron deficiency problems.

Early diagnosis and treatment of iron deficiency is essential since symptom reversal is difficult to achieve once the plants exceed 3 to 5 weeks of age.

**Disease:**
**MANGANESE DEFICIENCY**

**Host:** Cucumber *(Cucumis sativus)*

**Cause:** Deficiency of manganese

Manganese deficiency symptoms may occur whenever manganese levels in the soil fall below the amount essential for normal growth of the plant. This value is about 2 ppm for many soils, but will vary with soil type and soil chemistry. Manganese may be present in amounts sufficient for plant growth and development, but it may be in an insoluble (unavailable) form if the soil pH exceeds 6.0. Consequently, management of soil pH is an important aspect of controlling manganese deficiency in plants. This is especially important on coral sand or plateau soils where high pH values are common.

**Symptoms:** Manganese performs an essential role in 25 or more enzyme reactions in plant metabolism. Manganese, therefore, is essential to normal plant growth, development and reproduction. Deficiency of this mineral nutrient will result in the development of characteristic symptoms.

The first symptom of manganese deficiency is the appearance of irregular patches of yellow tissue between the veins of leaves of deficient plants. The chlorosis (yellowing) becomes progressively more intense and involves additional amounts of leaf tissue with time. In cases of severe deficiency, the center of the chlorotic areas will die and become brown in color. This will give affected leaves a mottled pattern with interveinal areas showing various shades of yellow to yellow-green with irregularly arranged, dead, brown lesions. The veins retain normal green color and stand out in relief against the general yellow background of the interveinal areas. Leaves and stems of manganese-deficient cucumbers remain small in size, and the plants will be stunted.

The disease has been referred to as speckled yellows, bold chlorosis or marsh spot in different crops. Youngest leaves may be most severely affected in plants such as tobacco and citrus; the oldest leaves usually are most severely affected in tomatoes, cabbage, lettuce and beets.

Cotyledons of beans from manganese-deficient plants will manifest sunken, brown, necrotic centers.

**Control:** The rate of application of manganese to soil should be determined by testing the soil to indicate the amount of available manganese present, soil reaction (pH) and the exact amount of manganese required for good crop growth. As a general rule, about 20 kg/ha of manganese



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sulfate is satisfactory for soils deficient in manganese. This fertilizer supplies manganese and, in addition, will result in reduction of the pH in high pH (coral sand) soils.

**Disease:**
**POTASSIUM DEFICIENCY**

**Host:** Chinese cabbage *(Brassica pekinensis)*

**Pathogen:** Deficiency of potassium

**Symptoms:** Margins of older leaves become chlorotic or "bronzed" in appearance when chinese cabbage (or other members of the Brassica family) is grown under conditions of low levels of potassium in the soil. This symptom frequently is referred to as tip burn. The bronzing will continue to develop on the leaf; the areas of the leaf which first indicated potassium deficiency symptoms will turn brown as leaf cells die. Severely affected leaves will show large, irregular patches of dead or "scorched" tissue. Leaf puckering or local areas of curling also will appear on plants with severe potassium starvation. Plants frequently will be distorted in appearance and dwarfed in size when deficient in potassium. All, or most, leaves may show symptoms during late stages of plant development under conditions of low levels of soil potassium. The leaves will be distorted and chlorotic, with patches of necrotic tissue under these circumstances.

Potassium is released from dead or dying cells in the oldest leaves and is readily translocated to the young leaves. Consequently, young leaves may remain vigorous, green and healthy for some time after the lower (oldest) leaves develop severe symptoms.

Most Seychelles' soils that have been cropped for any length of time are very low in potassium. The original amount present in these soils (especially the coral sands) is low, and potassium is readily leached from these soils as it is released from the organic component of the soil once the soils are broken for cultivation. Potassium deficiency is a potential problem on the crops grown in these soils.

**Control:** Control of potassium deficiency will depend upon the integration of several soil management practices. Potassium availability (solubility) decreases in soils with pH values exceeding 7.0. Consequently, the use of potassium-containing, acid-forming fertilizer, such as potassium sulfate, will be required to supply potassium and to lower the soil pH on alkaline soils. Potassium is leached from sandy soils more rapidly than from red-earth or clay soils. Different amounts of potassium are removed from the soil by different crops. Original levels of potassium are higher in some soils than in other soils. All of these factors must be considered in recommendations for potassium fertilizer placement. Each recommendation should be made on the basis of the



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**Disease:**
**ZINC DEFICIENCY**

**Host:** Orange and other *Citrus* spp.

**Cause:** Deficiency of Zinc

**Symptoms:** Zinc is referred to as a microelement or minor element since it is needed in small quantities for plant growth, development and reproduction.

A variety of symptoms develop on citrus trees when demand for zinc exceeds the amount available in the soil. The development of irregularly shaped patches of various shades of yellows and greens in the leaf tissue between the veins is the most frequently observed leaf symptom. The veins stand out prominently as dark-green bands along the midrib and lateral veins. This symptom is referred to as "mottle leaf" or "frenching."

Under conditions of acute deficiency, leaf stunting also may occur, resulting in smaller, narrower leaves. Terminal shoots may die, resulting in a "die-back" symptom. Affected trees assume an irregular or "ragged" appearance as dead branches project beyond the canopy. Quantity and quality of fruit from zinc-deficient trees will be seriously reduced.

**Control:** Foliage applications of 0.5 percent zinc sulfate or zinc sulfate with hydrated lime is the most satisfactory method of controlling zinc deficiency in citrus. Zinc oxide also may be used. Two or more applications are generally necessary. Soil application of zinc sulfate may be effective on some soils, but the success of this method depends on soil type, soil reaction and soil chemistry. It requires a balance of these factors difficult to achieve on many soils.

**Disease:**
**SALT TOXICITY**

**Host:** Prune de France *(Chrysobalanus icaco)*

**Cause:** Salt from sea spray

**Symptoms:** This disease is included to illustrate a physiopathogenic disease. Physiopathogenic plant diseases can originate as a result of exposure of plants to levels of chemicals or physical factors in the environment exceeding the lowest tolerance levels of individual plant species. They also can originate as a result of deficiencies of some essential factor required for normal plant growth, development and reproduction. Toxicity symptoms develop in plants exposed to salt in quantities that exceed the lower tolerance limits of the plant.

The plum coco (prune de France) plant illustrated was growing within 100 feet of high tide zone near Grand Anse. Salt spray was deposited on the leaves during periods of strong winds during the southeast monsoon season. The salt on the leaves may have resulted in the removal of water from the vein endings along the margin of the leaves. This action resulted in a drying of the margins of the leaves as water was lost from the leaf cells. On the other hand, salts (sodium chloride and salts of magnesium and potassium, etc.) may have been absorbed into the cells along the leaf margins in quantities exceeding the lowest amounts that could be tolerated by the leaf cells of the plant. The cells, consequently, may have been killed by the high salt concentrations, resulting in the symptoms illustrated. All plants have different salt tolerance levels. Many plants, therefore, are able to grow in a seaside environment with little detriment from salt spray.

Salt toxicity symptoms commence as small brown lesions of dead tissue on the leaf margins. As injury becomes more serious, large diffuse areas of brown tissue develop on the leaves. In extreme cases the entire leaf may be killed, and defoliation will occur. The color of salt-injured leaves may vary from tan to brown to brick red. This symptom is referred to as marginal scorch, leaf scorch or firing since the symptoms resemble those that would develop as a result of injury by fire.

Leaf scorch, caused by high concentrations of calcium and sodium chloride in the soil, has been identified in mangoes from India.

**Control:** Control of salt toxicity is difficult if plants are subjected to sea spray. If damage is slight and salt deposition diminishes, the plants may recover. Overhead irrigation shortly after exposure of plants to salt spray will remove salt on the leaves and prevent symptom development.



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# Common Insect Pests

# COMMON INSECT PESTS

**MEDITERRANEAN FRUIT FLY** *(Ceratitis capitata)*

This insect is potentially one of the most destructive pests in the Seychelles. It is known to attack well over 100 species of fruits and vegetables. The adult (Figure 1) is about two-thirds the size of a house fly. It has a yellowish body with a tinge of brown, especially on the legs. The wings have brownish yellow markings. The adult female fly is distinguished from the male by having an ovipositor or egg-laying structure at the tip of the abdomen. The head of the male has two long black bristles, which are flattened into diamond-shaped tips. Adult flies lay their eggs in clusters just below the epidermis of fruits and vegetables. Several hundred eggs can be deposited throughout the adult lifespan, which may last for two or more months.

The larvae, or immature stage (Figure 2), of the med-fly is the most destructive form. The best character for distinguishing med-fly larvae is the appearance of caudal spiracles located at the tail end of the larvae. Larvae feed on the fruit or vegetable as they develop and cause extensive damage. Characteristic damage to peppers and passion fruit is shown in Figures 3 and 4, respectively.

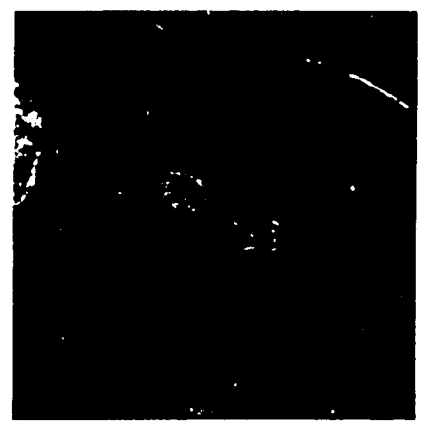

Figure 1

Figure 2

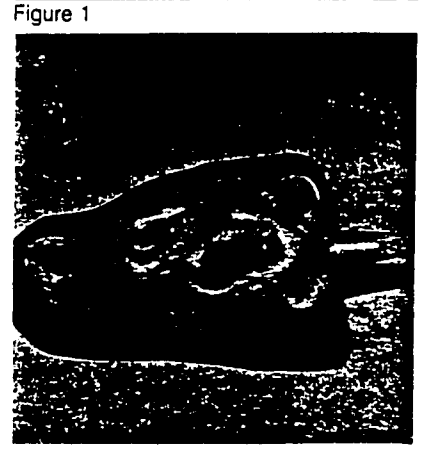

Figure 3

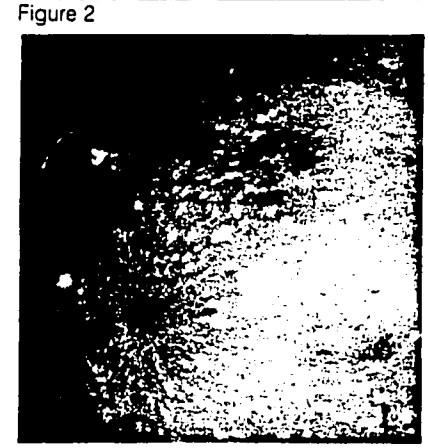

Figure 4



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**DIAMONDBACK MOTH** *(Plutella xylostella)*

This is the most important insect pest of cabbage. Adult moths (Figure 5) have a characteristic diamond-shaped pattern on their backs. They are approximately 1.5 cm in length and are active at night. Several eggs are laid on a single plant. Feeding by the small larvae (Figure 6) causes extensive damage. There almost always are several larvae on each plant which tend to congregate on the undersides of leaves. Feeding by these larvae on leaves of young plants results in large holes in leaves as the plants mature. These holes are often mis-identified as snail damage. When the larvae mature, they form small silken cocoons, normally on the undersides of the leaves, and pupate. Development from eggs to adults requires less than two weeks. Application of insecticides during the pupal stage is not effective. Also, there is good evidence to show that the diamondback moth is becoming resistant to Decis, one of the most commonly used insecticides. Growers are encouraged to use Dipel or some other formulation of *Bacillus thuringiensis*. Although the *Bacillus* acts more slowly in killing *Plutella*, there are no known cases of resistance. Also, beneficial insects and spiders are not harmed when *Bacillus thuringiensis* is used.

Figure 5

Figure 6

**BEAN POD BORER** *(Maruca testulalis)*

This insect is an important part of a complex of insect pests attacking beans. The adult is a small white moth, which holds its wings in a flattened position when at rest. Adults, which are from 1.5-1.8 cm in length, lay their eggs on the flowers, growing tips or young bean pods. The larvae (Figure 7) bore into the bean pods and cause extensive damage. Also, they attack flowers and ter-

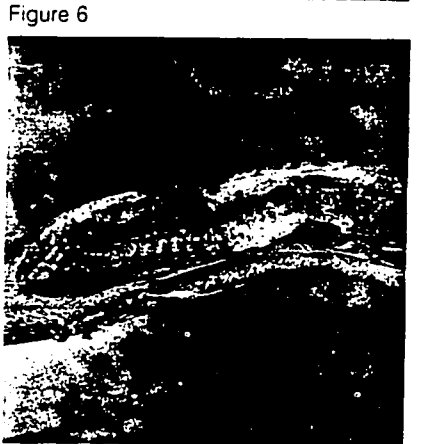

Figure 7



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minals of the plants and sometimes web these structures together. When larvae are inside the pods, application of insecticides is not effective.

**ARMYWORM** *(Spodoptera spp)*

Another destructive caterpillar on cabbage and some other crops is *Spodoptera* spp. (Figure 8). Members of this group are much larger than *Plutella*, often reaching a length of 30 mm. They can penetrate the heads of cabbages and often go unnoticed until the damage is extensive. Larvae are dark brown to almost black and may have a yellow stripe along each side. Adults (Figure 9) are approximately 2.75 cm and are active during the night. Eggs are laid in masses of a hundred or more, but normally only a few survive to maturity. Fortunately, this pest rarely reaches high populations. It is likely that this pest may become more important as areas planted to cabbages and other vegetables increase. Outbreaks of *Spodoptera* have occurred in other parts of the world due mainly to insecticide overuse, which brings about resistance and destruction of the natural enemies of *Spodoptera*.

Figure 8

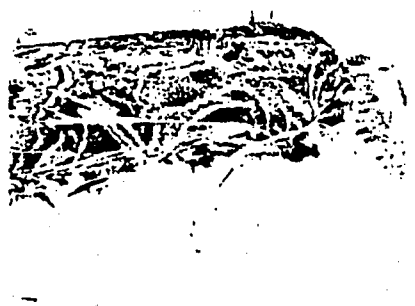

Figure 9

**LARGE CABBAGEWORM**
*(Crocidolomia binotalis)*

Damage to cabbage by these caterpillars is often thought to be caused by *Plutella*, but the large cabbageworm feeds primarily on the young, tender foliage at the center of the plants. The larvae (Figure 10) reach a length of about 2 cm when mature and commonly occur in groups of 2-5 or more per plant. If left untreated, this species can completely destroy a cabbage crop in

Figure 10



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a short period of time. An adult is shown in Figure 11. Fortunately, most of the chemicals presently used to control *Plutella* also are effective against the large cabbageworm. It is likely that this pest will increase in importance as the areas planted to cabbage are increased. Typical damage by the large cabbageworm to a cabbage plant is shown in Figure 12.

Figure 11

Figure 12

**A CATERPILLAR OF CUCURBITS** *(Diaphania indica)*

This small (less than 2 cm) caterpillar (Figure 13) is often found feeding on leaves of squash and other cucurbits. When the larvae approach maturity, they have a white stripe along each side of their backs. Actual damage, in terms of yield reduction, is difficult to assess, but it is likely that extensive feeding (Figure 14) by a dense population of these insects reduces yields directly and allows plant pathogens to invade the leaf tissue more easily.

Figure 13

Figure 14



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**THE ROSE CHAFER** *(Adoretus versutus)*

Although there are several beetles that feed on the foliage of fruits and vegetables, the rose chafer (Figure 15) is most important. Adults are brown, oval-shaped beetles about 1.2 cm in length. Damage to the plants is caused by the adult beetle, which may go unnoticed because of its night-time activity. Because this beetle feeds on the crop during the night and retreats to resting areas during the day, decisions to apply chemical treatments are based on the damage caused by this insect. They are particularly fond of the leaves of beans (see damage in Figure 16), okra and eggplants. Damage by the rose chafer is often confused with that caused by snails.

Figure 15

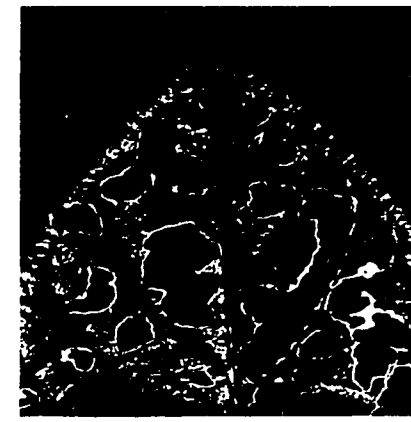

Figure 16

**LEAF-FOOTED BUG** *(Leptoglossus australis)*

This insect gets its name from the fact that part of its hind legs are flattened or leaf-shaped. Adults (Figure 17) and nymphs (Figure 18) feed by inserting their mouthparts into the plants and sucking out the plant

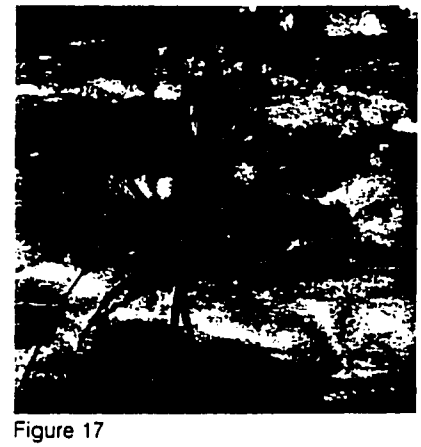

Figure 17

Figure 18



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juices. Outbreak populations have been observed on margoze on Mahe, but beans and tomatoes also are susceptible to attack by this insect. Adults are about 1.8 cm long and brown to brownish-black. Females lay several eggs together in a mass, and several masses may be deposited over a period of a few weeks. Young nymphs begin feeding soon after they hatch and continue to feed throughout their adult lives. The immature stages are often found in groups. Damage to beans may not be noticed until several days after feeding occurs. The mouthpart is inserted into the pod of beans and into the bean seed. Seeds, injured by feeding activities of this pest, will not develop.

**SCALE INSECTS and MEALY BUGS**

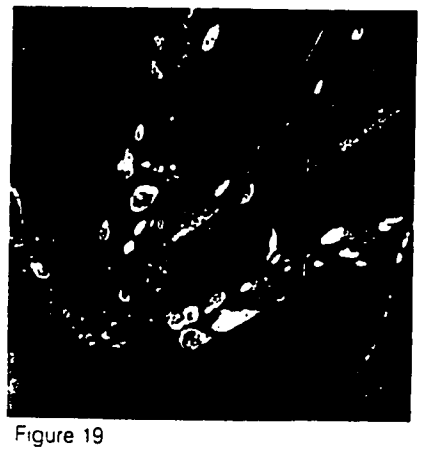

Figure 19

Scale insects (Figure 19) and mealy bugs are very abundant, especially on citrus and ornamental plants, although they occur on some vegetables. They get their names from the fact that their bodies are covered with a waxy scale-like covering. These insects are almost always found in groups and are often attended by ants, which feed on the sweet material secreted by the scales. Although scale insects and mealy bugs are able to crawl when they first hatch from the egg, the adults attach themselves to undersides of the leaves and stems of plants and remain stationary. Many of the scale insects resemble small tortoises while mealy bugs may be covered with a soft, cottony or waxy material. Direct damage to the plants is due to feeding by these insects as they insert their mouthparts into the plant tissue and also by the production of a sweet secretion (honeydew), which supports the growth of sooty mold fungi on the leaves. This reduces the amount of light that contacts the leaves. The end result is an overall reduction in plant growth and vitality, or leaves may die and fall off. Although there are many species of scale insects and mealy bugs, many are kept under control by beneficial insects such as ladybeetles and parasites.

## APHIDS

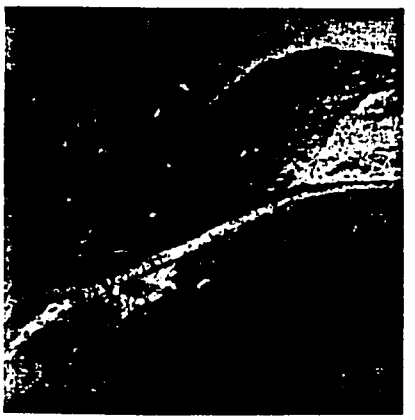

Figure 20

There are several species of aphids in Seychelles attacking a wide variety of fruits, vegetables and ornamental plants. Aphids (Figure 20) are small, pear-shaped, soft-bodied insects frequently found clustered together in large numbers. They have piercing, sucking mouthparts and are capable of causing serious damage to plant leaves due to their feeding activity. Feeding activities of large numbers of aphids cause leaves to curl and drop off. They also feed extensively on young developing leaves and buds. They secrete a sweet material (honeydew) as do many scale insects. This honeydew provides nourishment for growth of "sooty mold" fungi, which blocks the sunlight to plant leaves. Honeydew is fed upon by ants, which guard the aphids from potential predators and parasites. Aphids have a pair of projections from the end of their body. Some aphids may have wings. Large populations can build up in a very short time due to their very high reproductive capacity. In addition to the direct damage due to their feeding, some aphids are capable of transmitting plant pathogens.

## WHITEFLIES

Figure 21

Members of this group resemble tiny moths, but the adults are very small (only about 2 mm). Adults are white and are easily disturbed. In general the immature stages are not active and are found attached to the undersides of the leaves, especially cassava, one of their favorite host plants. The immature forms resemble tiny scale insects. Whiteflies feed upon a wide variety of host plants and may be responsible for considerable direct economic losses. These insects also are able to acquire viruses from virus-infected plants and transmit these viruses to healthy plants.



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**MOLE CRICKETS** *(Gryllotalpa africana)*

These insects burrow beneath the soil and are most destructive to the seedling stage of many plant species. They are brownish colored and reach a length of about 2.5 cm (Figure 22). They have short antennae, and the front legs are modified into flattened or spade-like structures for digging. They particularly like burrowing in moist places, such as seedbeds, where they feed extensively on the roots of young plants.

Figure 22

**OTHER INSECT PESTS**

In addition to those insect pests listed above, there are many more that are not included. Many of these species may reach pest status under given circumstances. Some additional species include stink bugs (Figure 23), thrips (Figure 24) and termites (Figure 25). Many of these pests have been introduced into the Seychelles without their natural enemies, which may keep them under control in their native country.

Figure 23

Figure 24

Figure 25



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## NON-INSECT PESTS

Besides insects and plant diseases of fruit and vegetable crops, there are several pests that cause extensive damage if they are not controlled.

Figure 26

Mites are tiny, almost microscopic, spider-like pests, which attack a wide variety of fruit and vegetable crops. One of the most commonly occurring groups of mites is the spider mite *(Tetranychus)*. These mites can occur in dense populations on the undersides of leaves where they spin a loose, thin web of silk among which the colony lives. Damage by mites is due to their feeding (Figure 26). They insert their mouthparts into the plant tissue and remove plant juices, causing the tissue to become yellowish and discolored. Excessive feeding by mites causes leaves to drop. Like aphids, scales and whiteflies, mites have an extremely high reproduction rate, and populations can become large in a matter of a few days. Mites are not capable of flying but are often dispersed by the wind from one crop or field to another. Use of the improper chemical (such as Carbaryl) may actually encourage the build-up of mite populations by eliminating natural enemies such as some fungi (which attack mites) and ladybeetles. Excessively dry conditions also may encourage large mite populations.

The silver rust mite on citrus can be a serious pest. Feeding by this mite causes unsightly brown spots on citrus fruit. Feeding by large populations of mites before the fruit develops can cause it to drop prematurely.

Figure 27

Figure 28

Other serious non-insect pests are the species of giant african land snail *(Achitina* spp.) (Figure 27). Damage by these snails and slugs can result in serious yield reduction or total loss of the crop. Typical damage to okra leaves is shown in Figure 28.

Besides pests mentioned above, serious damage to plants (or fruits) can be caused by rodents, weeds and some species of birds.



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## ACKNOWLEDGEMENT


Appreciation is expressed to Dr. F. H. Smith, Extension Plant Pathologist, Clemson University for the following illustrations: Bacterial leaf spot of tomato, bacterial wilt of tomato, Cercospora leaf spot of bean, downy mildew of cabbage, Fusarium wilt of tomato, Sclerotium stem blight of bean and white rust.




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APPENDIX 4: Dr. Shepard's End of Tour Report

Quarterly Progress Report
USAID/SECID Food Crops Research Contract
Seychelles
July, August, September, 1981

Reported by the Contract Entomologist

## INTRODUCTION

Much of the two month period (July - August) allowed for the Contract Entomologist was spent gaining familiarity with the current insect and mite pest situation on fruits and vegetables. Assessment of current insect and mite control practices was made on several growers farms on Mahe and Praslin. Identification of some of the major arthropod pest problems was greatly facilitated by the Chief Research and Development Officer, the Pest Control Research Officer, a highly qualified Peace Corps volunteer, several extension agents,and growers. In addition to becoming acquainted with the scope and severity of insect and mite problems on major food crops, entomological research activities were organized, prioritized and research set in motion.

As reported earlier in the Implimentation Plan, the following research areas are those which needed immediate attention and form the basis upon which long term economically and ecologically sound insect and mite control programs can be developed.

## RESEARCH ACTIVITIES

a. Insect and Mite Survey, Collection and Identification:

A major effort is in progress to survey, collect and identify pest and beneficial species of insects and mites. Several hundred insects and mites have been collected and many representative examples of pest and beneficial species have been labelled and

preserved in vials or pinned for observation and storage in Schmidt boxes. The specimens were obtained from 1.) a U.S.D.A. light trap, installed at the Farmer's Training Center, Anse Boileau and 2.) surveys made during visits to growers' fields. Thus, a permanent reference collection has been started and should be valuable for training, demonstrations, seminars and workshops. Some of the species which were collected as immatures were reared to adulthood in order to identify the various life forms. Many species have been identified to the species level, others have been sent to the British Museum (U.K.) for identification by expert taxonomists. The light trap will be in operation on a continuous basis in order to determine the seasonal abundance of important species.

Results from field surveys carried out on Mahe and Praslin revealed several important and potentially important insect and mite pests. One of the most important insect pests of several fruits and vegetables is the Mediterranean fruit fly, Ceratitis capitata. This pest is widely distributed on Mahe and Praslin and is especially severe on citrus, mango, guava, passion fruit and capsicums. During the surveys conducted in July and August, over 90% of the passion fruit had sustained fruit fly damage in some areas. Interestingly, dissection of over 100 fruit from a range of locations did not produce fruit fly larvae. It may be that although passion fruit is an acceptable host, it may not be a suitable host for the fruit fly development. However, attacks by the flies causes unsightly blemishes on the skin of the fruit and heavy attacks produces deformities and early fruit drop. Additional comments about the fruit fly research effort are given later in this report.

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Economically damaging populations of other insect pests and the associated host crops are as follows: 1.) The rose chafer, Adoretus versutus, is a serious defoliator on several crops, 2.) Termite colonies were found in the basal portion of the vines of passion fruit, 3.) Heavy infestations of thrips were observed and collected from strawberry plants. These have been sent away for species identification. 4.) All stages of the leaf-footed bug, Leptoglossus australis, were found in high numbers on Margoze. These fruits had sustained serious damage as a result of this insect pest, 5.) The diamond-back moth, Plutella xylostella, was found to be the major pest on cabbage. 6.) An armyworm, Spodoptera sp. is becoming more abundant on cabbage, probably as a direct result of insecticide overuse on this crop for control of the diamond back moth, 7.) Scale insects are major pests of citrus and other fruits and secretion of honey dew by these pests causes a rapid build-up of sooty mold which interferes with photosynthesis, 8.) Aphids and white flies are an important part of the insect pest complex on several crops. These two groups are undoubtedly transmitting many of the viruses which were found in fruits and vegetables, especially tomatoes, 9.) Flea beetles were present in extremely dense populations in sweet potato fields. Closer observations carried out by containing these beetles on sweet potato foliage revealed that significant leaf damage can result from large numbers of these chrysomellids, 10.) The red spider mite, Tetranychus sp. was causing damage to the foliage snap beans in several locations. These were especially abundant where heavy and repeated uses of insecticides had created "resurgences" of their populations.

Many other potentially important insect and mite species were observed but those mentioned above were considered most serious during July and August, 1981. Control recommendations were made when possible to do so based on prior experience with similar pests.

Upon returning in June, 1982, surveys of crops will continue along with assessment of damage caused by these pests.

b. Identification and Control of Arthropod Vectors of a Tomato Virus:

In order to attempt to identify insect vectors which might be transmitting viruses to tomato plants, insects were collected from tomatoes and adjacent vegetation. Two families of insects (Lygaeidae and Myridae) were present at the time of the observations. The myrids were especially abundant on a wild host plant, Pissat de Chine (*Cleome viscosum* - Cleomaceae), which were present in and around the tomato fields. As reported by the contract plant pathologist, 60 myrids and 12 lygacids were caged on the virus infected tomato plants using 4" X 12" sleeve cages constructed from bamboo and panty hose. After allowing these insects to feed for two days, they were transferred into 2.5' cubical cages containing uninfected tomato plants. After three weeks no symptoms of virus developed. It is unlikely that these insects vectored the tomato virus. Searches for other possible insect vectors of the tomato virus are continuing.

c. Seasonal Abundance, Distribution and Control of Fruit Flies:

Experiments were begun in July, 1981 in order to determine the seasonal abundance and distribution of the Mediterranean fruit fly (medfly) *Ceratitis capitata* on Mahe. These experiments were designed

in cooperation with the Pest Control Research Officer and are being carried out by him in my absence. Eight different trap sites were chosen and each of four different types of fruit fly traps were placed at each site. Trap sites were chosen to reflect a cross section of different altitudes and proximities to different fruit and vegetable crops. Several modifications of fruit fly traps were used in preliminary experiments in order to find those best suited for envir mental conditions in the Seychelles. Plastic traps previously used for survey of fruit flies were baited with the sex pheromone Trimedlure and the insecticide Dipterex. Studies involving trapping adult flies using a standard gypsy moth trap and Trimedlure revealed that this trap was much more efficient. For example, 12 flies were trapped in the gypsy moth trap baited with five drops of Trimedlure compared to none in the conventional plastic trap during a 1 day period. Thus by a series of preliminary experiments, several modifications of trap designs were carried out by placing these traps in several locations for several weeks.

Although the gypsy moth trap was more efficient in sampling fruit fly populations, it was not durable enough for use in a trapping program. The heavy rains and intense sunlight destroyed the traps after a few weeks. Thus a new trap was developed which contained the features of the gypsy moth trap (e.g. a sticky panel inside instead of insecticides) and the more durable plastic traps.

By mid-August, 1981, a full-fledge trapping program was initiated and all traps (four at each of eight locations) were checked twice per week and flies were counted and removed. The following is a table of

trap site locations and general description of adjacent fruit or vegetable crops:

| Trap site | Associated crop(s) |
|---|---|
| Grand Anse Experiment Station | Passion fruit, other fruit crops |
| Souvenir | Citrus |
| Farmers Training Center | Passion fruit, some tomatoes, Papaya |
| Hermitage | Tomatoes |
| Lafari | Mixed crop of vegetables, esp. tomatoes |
| Jumeau | Several kinds of citrus |
| Sadeco | Peppers, passion fruits, tomatoes |
| Ferrari | Primarily citrus |

The four kinds of traps used in the study were:

(i) Plastic containers 12X12X7 cm (yellow or orange) baited with four drops of the attractant Trimedlure and charged with an insecticide Dipterex.

(ii) Flat white plastic container (13X13X4.5 cm) also containing Trimedlure and Dipterex.

(iii) Plastic traps (as in ii) containing the attractant, but instead of insecticide, a sticky panel from the gypsy moth trap was stapled inside the lid.

(iv) Standard gypsy moth traps containing Trimedlure

In order to determine if other species of fruit flies were present, two additional sex attractants were imported and placed in traps. These attractants were Cue Lure which is used to trap Dacus spp. in Australia and other parts of the world, and methyl eugenol which is attractive to other species of fruit flies. Several adults of flies

were mailed to taxonomists in Australia for positive identification.

The extent of infestation of various fruits and vegetables is being determined along with observations of the possibility of other species of fruit flies being present. This is being carried out by making collections of infested fruits and bringing them to the Experiment Station. These fruit-fly infested fruits are placed in specially constructed wooden trays which contained sand. Fruit fly larvae exit the fruit and pupate in the sand. Pupae are sieved from the sand and held in the laboratory until adults emerged. Those adults which emerge are identified along with any possible medfly parasites.

Results from experiments carried out this quarter reveal that medflies are concentrated in areas where citrus is grown. However, populations of adult medflies were found in all eight locations and the potential for economically damaging populations was evident. Highest populations of medflies were present at Grand Ause, Mr. Jumeau's citrus farm and in Mr. Ferrari's citrus (Tables 1 and 2). To date only the Mediterranean fruit fly has been found.

Except for a slight decline in numbers of medflies caught during October 1981, the medfly population density has remained relatively even when catches from all locations are combined. However, numbers of medflies collected at the Jumeau trap site increased significantly from September through November, 1981, while there was a decline in numbers of medflies caught in traps at Grand Ause.

In almost every case, the modified plastic trap with a sticky panel inside yielded consistantly higher numbers of flies at all trap sites. It may be that traps baited with insecticide may have a repelling influence on the medflies.

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Table 1. Numbers of adult Medflies caught in traps at eight locations on Mahe, Seychelles. 1981.

| Trap Site | Collection Date | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | July30 | July31 | Aug 2 | Aug 3 | Aug 4 | Aug 5 | Aug 7 | Aug10 | Aug18 | Aug21 | Aug25 | Aug28 |
| Grand Anse | 4 | 6 | 15 | 3 | 6 | 3 | 6 | 6 | 29 | 17 | 30 | 16 |
| Souvenir | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| Farmers Training Center | 1/ | - | - | - | - | - | - | - | 0 | 0 | 2 | 0 |
| Hermitage | - | - | - | - | - | - | - | - | 1 | 4 | 1 | 1 |
| Lafari | - | - | - | - | - | - | - | - | 0 | 0 | 1 | 0 |
| Jumeau | - | - | - | - | - | - | - | - | 14 | 10 | 11 | 11 |
| Sadeco | - | - | - | - | - | - | - | - | 4 | 1 | 2 | 0 |
| Ferrari | - | - | - | - | - | - | - | - | 39 | 10 | 15 | 12 |

1/ Traps not yet placed at these locations.

Table 2. Monthly counts of medflies caught at eight trapping sites on Mache, Saychelles during August through November,1981.

| Trap Site | Month of Collection | | | | |
|---|---|---|---|---|---|
| | August | September | October | November | Total |
| Grand Ause | 104 | 103 | 38 | 45 | 290 |
| Souvenir | 3 | 3 | 7 | 18 | 31 |
| Farmers Training Center | 3 | 1 | 6 | 1 | 11 |
| Hermitage | 7 | 5 | 15 | 2 | 29 |
| Lafari | 1 | 1 | 2 | 13 | 17 |
| Jumeau | 52 | 14 | 73 | 142 | 281 |
| Sadeco | 7 | 13 | 10 | 0 | 30 |
| Ferrari | 83 | 108 | 25 | 36 | 252 |
| TOTALS | 260 | 248 | 176 | 257 | 941 |

d. Biological Control of the Diamond Back Moth, *Plutella xylostella* on Cabbage:

Besides a few collections which were made in order to check for the natural incidence of parasitism on the diamond back moth during the time the entomologist was in the Seychelles (July - August), no results from this aspect of the program can be reported this quarter. Although three species of parasites of the diamond back moth were introduced into the Seychelles from the West Indies during 1972, preliminary observations do not indicate that any of these species were established.

Esperimental cabbage plots are being planted (Feb., 1982) for the purpose of monitoring for the incidence of parasitism. Earlier correspondence with personnel at the Commonwealth Institute of Biological Control has provided information about the possibility of introducing parasites into the Seychelles for controlling the diamond back moth.

In conclusion, most of the entomological experiments will require the continuing efforts of the Pest Control Research Officer because of the short (two month/year) time period allowed under the terms of the contract. To date, good progress has been made and research which was begun during July and August, 1981, is continuing. However, it must be pointed out that the Pest Control Research Officer is already overworked with the many other duties that he must perform. Thus, the time available for carrying out entomological research is minimal.

During July and August, 1981, efforts were made by the entomologist to provide as much training as possible to personnel involved in the project. Information was provided to the Pest Control Research Officer, extension personnel, and to two young Seychellois trainees who worked with the entomology program. It is critical to the success of the program that further training be provided in the form of formal or short courses at qualified institutions outside the Seychelles.

Quarterly Progress Report

USAID/SECID FOOD CROPS RESEARCH CONTRACT-SEYCHELLES

July, August, September, 1982

REPORTED BY THE CONTRACT ENTOMOLOGIST

## INTRODUCTION

During this reporting period, the Contract Entomologist was present in the Seychelles only during the month of July. Herein is a summary of activities for this month.

As noted in previous quarterly reports the areas which are receiving the major research thrusts are: 1) insect and mite surveys, collections and identification 2) identification and control of arthropod vectors of a disease of tomatoes, 3) determination of the seasonal abundance, distribution and control of fruit flies and 4) biological control of the diamond-back moth, *Plutella xylostella*, on cabbage.

Other activities include providing training for Seychellois assistants, visiting growers farms and providing advice and writing articles for the local media.

## RESEARCH ACTIVITIES

a. Insect and mite surveys, collections and identifications:

In order to provide more comprehensive assessment of the insect fauna, the U.S.D.A. light trap, which was located at the Farmer's Training Center at Anse Boileau, was moved to Grand Anse. The trap was checked and emptied every few days and those insects which were not already in the collection, were mounted and labelled. Larvae, mites, aphids, and other soft bodied insects were preserved in 75% ethanol. Other specimens were contained in Schmidt boxes for easy

reference or for use in training, field-days, etc. Several hundred specimens have now been collected.

A suspected vector of the tomato disease was identified as a lygaeid in the genus Nysius. The species is either albipennis dist. or euphobiae horn. The taxonomy of this group is difficult because of lack of proper keys. Dr. M.H. Sweet, Texas A&M University made the generic determination.

An extremely high population of white flies were present on cassava during the month of July. Specimens have been sent away for species determination. We suspect this insect as a possible vector of a serious tomato disease. Results from these studies are reported under the next section.

Mites were obtained from leaves of papaya, cassava, and passion fruit by use of a Berlese funnel and by hand picking. Mites found associated with these crops are listed in Table 1. As noted in this table, several of these species are new to science. Although members of the family phytoseiidae are beneficial (predatory) the pest status of the other species cannot be discerned at this time.

The mite specimens were identified by H.A. Denmark, an internationally recognized acarologist. He is also providing specimens mounted on slides for use by personnel at the Grand Anse Experiment and Food Production Center.

b. Identification and control of arthropod vectors of a tomato disease:

Experiments which were begun earlier in cooperation with the contract plant pathologist, were continued through July. The focus of these experiments were on identifying possible vectors of a virus-like disease of tomatoes, if indeed the disease was vectored by arthropods. Results from earlier tests using lygaeids, myrids, and cica-

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dellids as possible vectors revealed no connection between these insect groups and the disease. These tests were conducted by caging these insects on infected tomato plants for 2-3 days, then removing them to uninfected plants in cuboidal 2.5 ft. cages. The case used in these studies to confine the insects to the infected plants is shown in figure 1.

As mentioned in the last quarterly report, the recent work has been to determine if white flies may be the vector of this disease. Several hundred white flies have been confined to cages on infected plants (about 50 flies per cage) and later transferred to large cages with uninfected plants. To date, no conclusive evidence is available which shows that the white flies are vectoring the disease. Research will be continued in order to identify the source and possible arthropod vectors of this disease.

c. Seasonal abundance, distribution and control of fruit flies:

Fruit fly trapping in eight locations on Mahe continued through July, 1982. Trap types which were used are as follows: 1) yellow plastic boxes (11.6 x 11.4 x 6.6 cm) (see Fig. 2A) 2) orange plastic boxes (11.6 x 11.4 x 6.6 cm) 3) white plastic boxes (13 x13 x 4.6 cm) containing sticky panels (see Fig. 2B) 4) white plastic boxes (as in Fig. 2B) with a block of DDVP-impregnated resin, and 5) white plastic boxes (as in Fig. 2B) with Dipterex. All of these traps were baited with Trimedlure (3 drops per trap). In addition, Steiner traps (Fig. 3) were baited with Cue-lure and methyl euguenol in order to determine if species other than *Ceritituss capitata* were present.

As reported in the last (April-May-June) report, numbers of med-flies were most abundant in areas where citrus was grown (Jumeau

and Ferrari sites). The population counts for July are shown in Table 2. The numbers of flies trapped in July were significantly fewer than those caught in May, when peak numbers were caught. Again, the yellow traps were preferred by the fruit flies over the orange ones. However, the most effective trap (and the easiest to use and maintain) was made from the flat white plastic boxes containing the DDVP-resin. Greater numbers of flies were collected in these traps with a lower coefficient of variability.

In addition to collections of med-flies in the pheromone traps, collections of citrus fruit were made and placed in wooden trays containing sand. As fruit fly larvae matured, they exited the fruit and pupated in the sand. The sand was then sieved and the pupae removed and maintained in the laboratory until adults emerged. This procedure was conducted in order to help determine if other species of fruit flies were present. Also, the incidence of pupal parasitism could be determined.

Results from these studies showed that no other species (other than med-flies) were present and no med-fly pupae were parasitized. Likewise, use of the Steiner traps revealed no new species of fruit flies.

d. Biological control of the diamond-back moth, *Plutella xylostella* on cabbage:

During the month of July, several hundred *Plutella xylostella* larvae were collected from cabbage in the field and reared to adults in the laboratory. The purpose of this was to determine if any parasites which were released in 1972 in the Seychelles, had become established. No parasites were detected during this month.

Arrangements have been made to ship parasites from Commonwealth Institute for Biological Control laboratories in Pakistan and Trinidad.

These parasites will be released during May, 1983 in untreated cabbage fields for control of the diamond-back moth.

Table 1. Mite species found on leaves of papaya, passion fruit and cassava on Mahe, Seychelles, July, 1982.[1/]

| Family[2/] | Genus | Species | Host |
|---|---|---|---|
| Phytoseiidae | Euseius | new species | papaya |
| Tetranychidae | Eutetranychus | banksi (McGregor) | papaya |
| Tenuipalpidae | Brevipalpus | phoenicis (Geijskes) | passion fruit |
| Phytoseiidae | Amblyseius | new species | passion fruit |
| Tetranychidae | Tetranychus | (species not known) | passion fruit |
| Cunaxidae | (not able to identify) | | passion fruit |
| Tetranychidae | Tetranychus | piercei McGregor | cassava |
| Phytoseiidae | Euseius | new species | cassava |
| Ascidae | Lasioseius | possibly new species | cassava |
| Tenuipalpidae | Brevipalpus | phoenicis (Geijskes) | cassava |

1/ Collections made by hand picking from leaves and by Berlese funnel.

2/ Mite identifications made by H. A. Denmark, Division of Plant Industry, Gainesville, Florida.

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Table 2. Numbers (Mean ± Std. dev.) of Mediterranean fruit flies caught per trap in five different trap types during July, 1982. Mahe, Seychelles.

| Sample Date | Trap Type[1/] | | | | | Totals |
|---|---|---|---|---|---|---|
| | ORNG | YELLW | FW-DIP | FW-STK | STRK | |
| July 7, 1982 | 6.1 ± 10.3 | 3.1 ± 3.9 | 3.2 ± 5.3 | 5.6 ± 9.4 | 22.0 ± 16.1 | 44 |
| July 13, 1982 | 6.8 ± 16.3 | 14.4 ± 18.1 | 11.4 ± 12.9 | 10.4 ± 15.5 | 39.2 ± 27.8 | 82 |
| July 21, 1982 | 5.6 ± 10.7 | 5.4 ± 9.3 | 6.2 ± 8.0 | 4.8 ± 5.1 | 22.5 ± 16.4 | 45 |
| July 28, 1982 | 1.2 ± 2.8 | 0.6 ± 0.7 | 3.1 ± 6.3 | 1.5 ± 3.0 | 9.6 ± 10.9 | 16 |

1/ ORNG = Orange traps with Dipterex®
YELLW = Yellow traps with Dipterx®
FW-DIP = Flat white traps with Dipterex®
FW-STK = Flat white traps with sticky panel
STRK = Traps with insecticide-impregnated block of resin (Strike®)

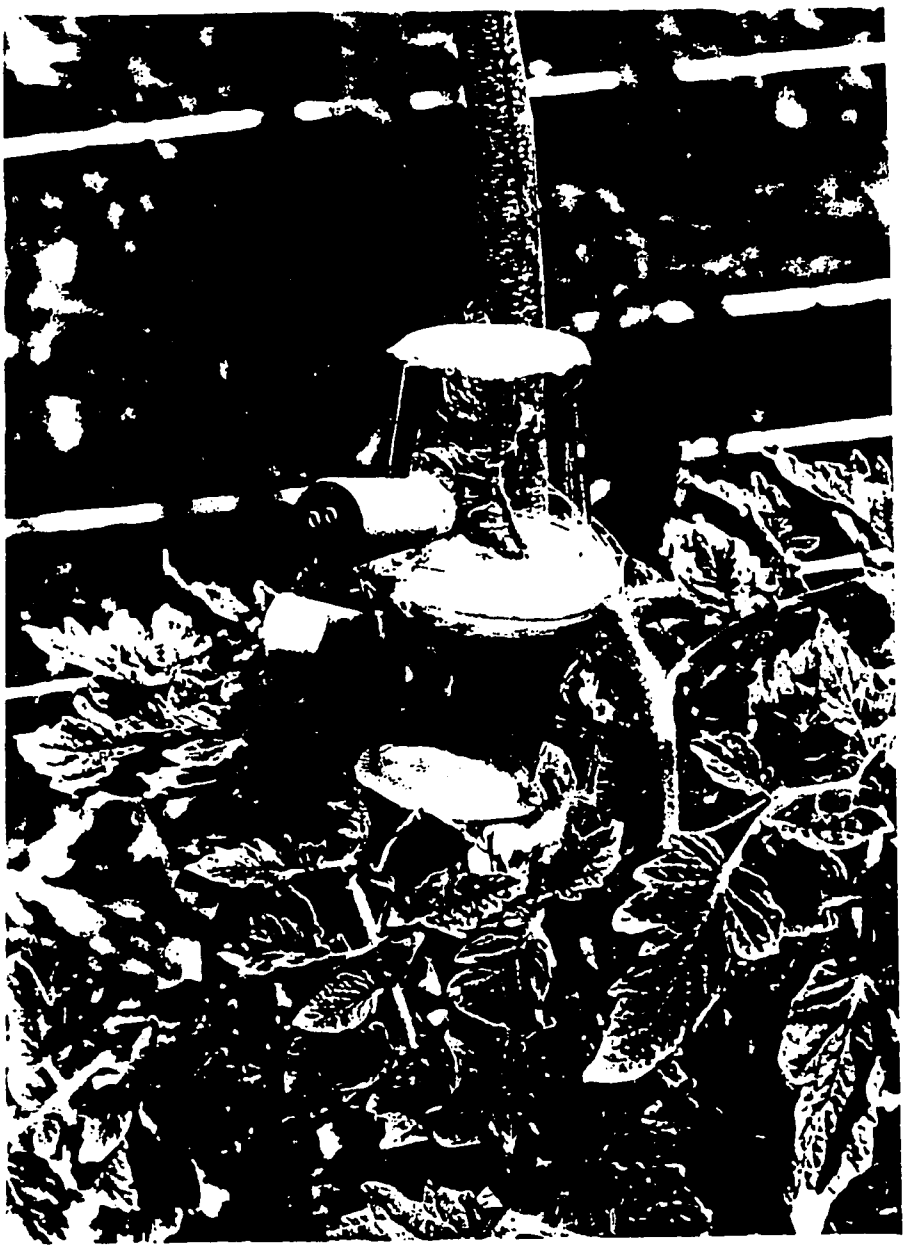

Figure 1. Plastic cup-cages used to contain white flies on diseased tomato plants.

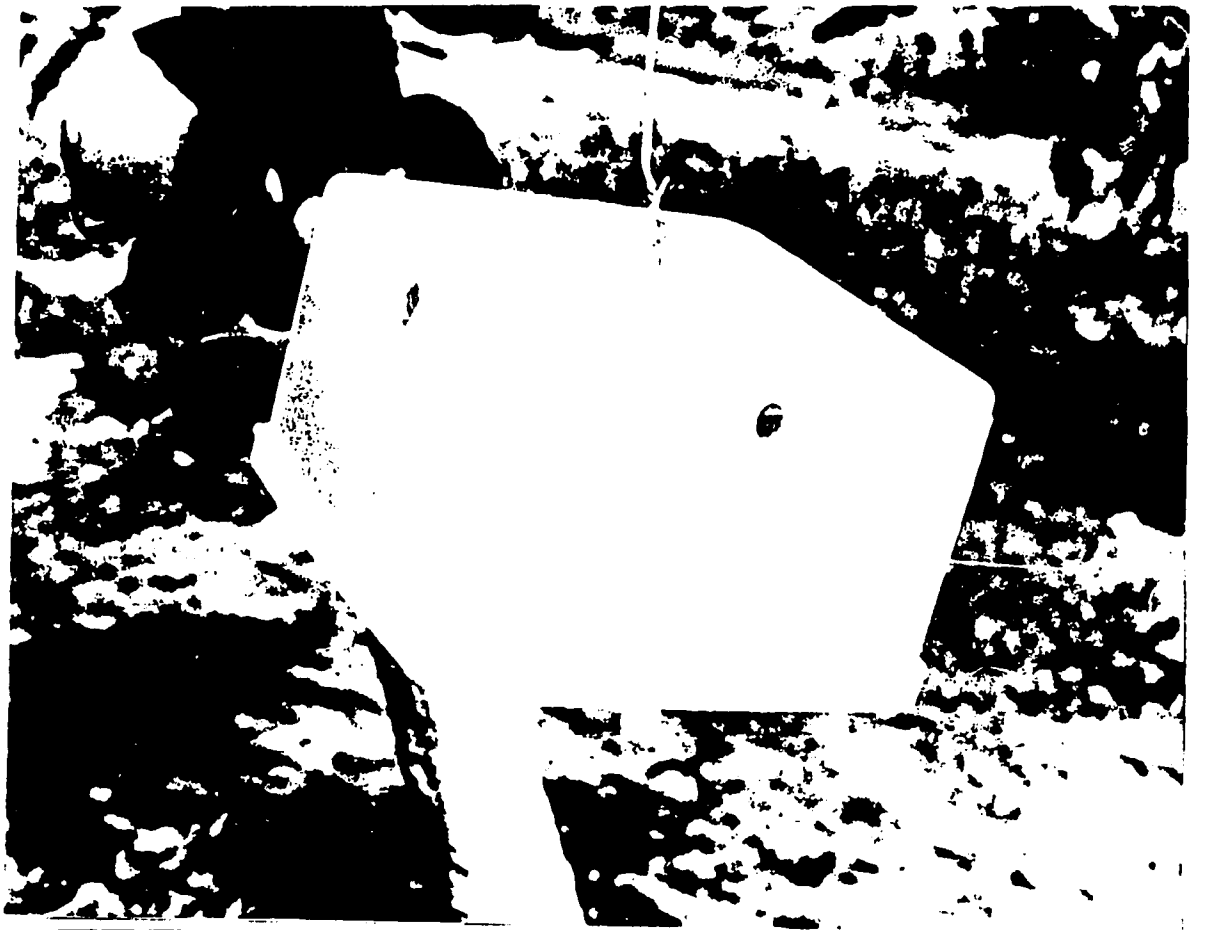

Fig. 2-A

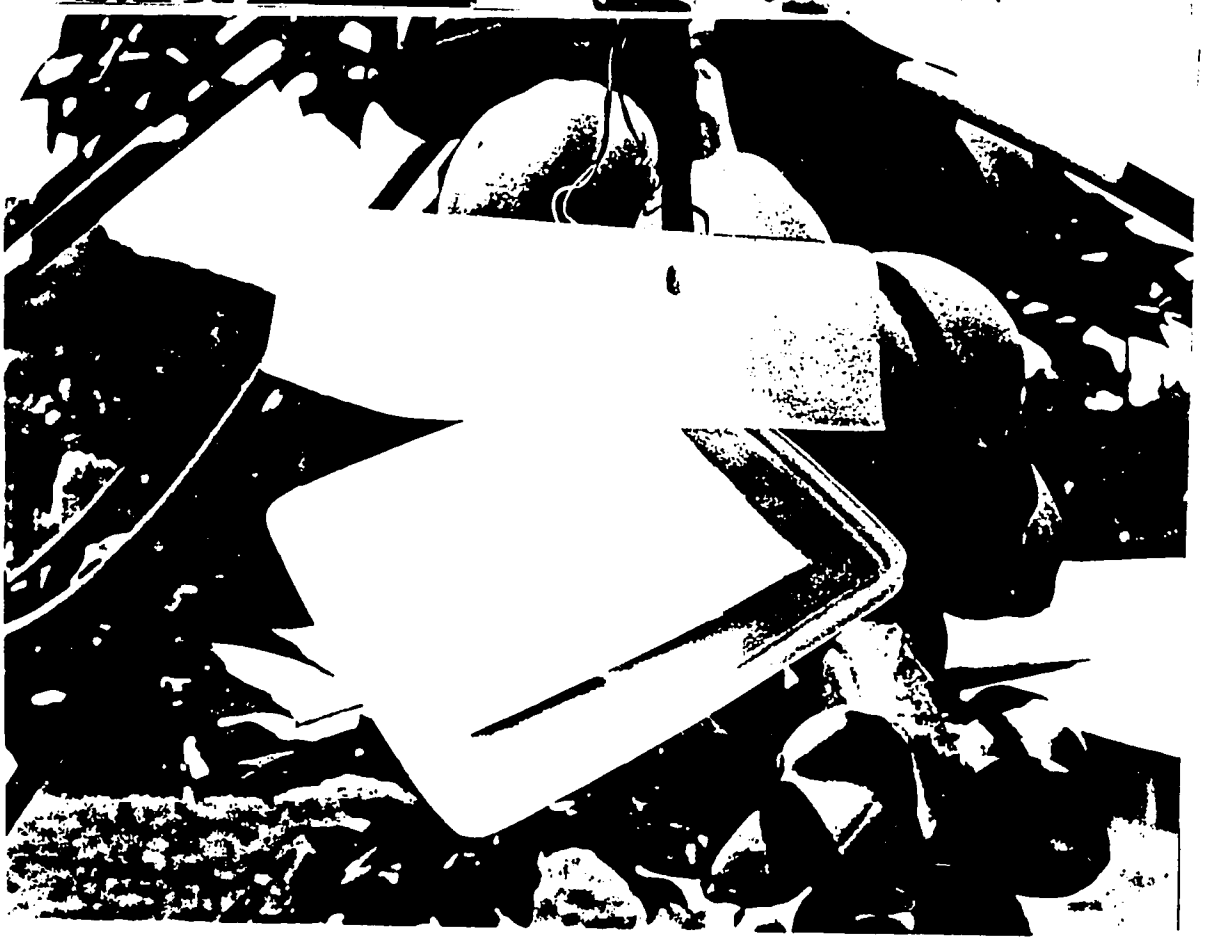

Fig. 2-B

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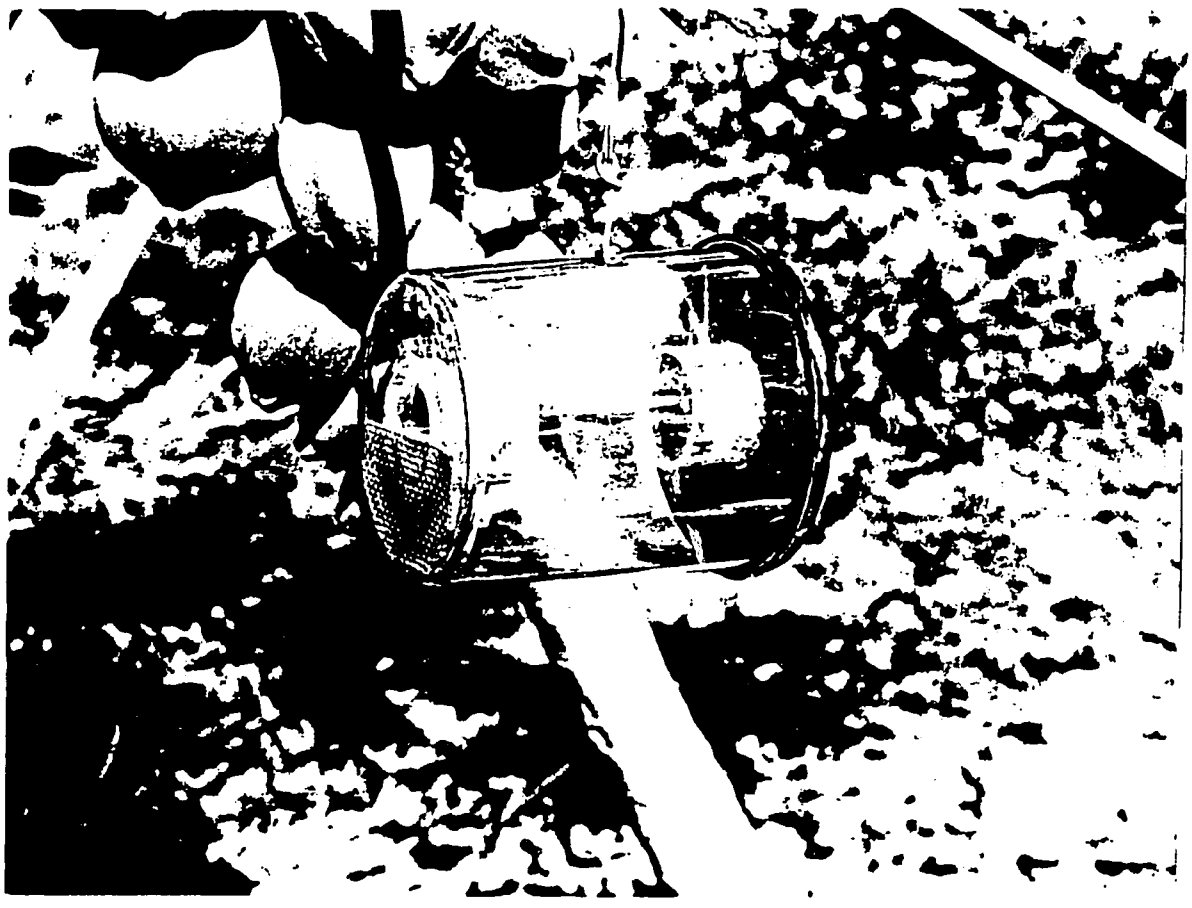

Figure 3. Fruit fly trap (Steiner trap) baited with either cue-lure or methyl eugenol.

QUARTERLY PROGRESS REPORT
USAID/SECID FOOD CROPS RESEARCH CONTRACT SEYCHELLES
APRIL, MAY, JUNE, 1982
REPORTED BY THE CONTRACT ENTOMOLOGIST

## INTRODUCTION

For this reporting period (quarter), the Contract Entomologist was present in the Seychelles for only one month (June). Activities reported herein have resulted from work conducted during this one month period and from ongoing research which was started during 1981. Surveys of growers farms were continued in order to identify major insect and mite pests. The severity of the damage caused by these pests also was assessed. Much emphasis during this quarter was placed upon attempts to identify the possible insect or mite vectors of a serious disease of tomatoes. The incidence of this disease often exceeds eighty percent of the tomato plants. A program of monitoring the seasonal and geographical abundance of the med-fly (Ceratitis capitata) was continued this quarter. In order to assess the possible baseline levels of parasitism of the diamond back moth, (Plutella xylostella), collections of larvae and pupae were made from several locations. These immature forms were kept alive in the laboratory until development to adulthood.

Other activities included writing articles for the local newspaper, extension activities such as visiting growers farms and providing advice. Also, a significant amount of time was spend providing training for Seychellois assistants.

## RESEARCH ACTIVITIES

a. Insect and mite survey, collection and identification:

Field surveys and a light trap are the primary sources for the insects which have been collected, pinned and placed in a permanent collection at the Grand Anse Experiment and Food Production Center. Many of the species have been identified and others have been sent away for identification by expert taxonomists. The U.S.D.A. light trap has been relocated from Anse Boileau to Grand Anse in order to determine if there are any regional differences in the insect communities of the two regions. As the permanent insect collection is expanded, so will its usefulness for training, demonstrations, seminars and workshops. Considerable time has been devoted to instructing Seychellois trainees in the techniques of proper collecting, labeling and preserving insect and mite specimens.

An additional pest species has been found attacking the leaves of squash, cucumbers, and melons on Mahe and Bird Island. The larvae of this pyralid moth (Diaphania indica saunders) feed extensively on the leaves and may be causing an increase in infection by diseases by providing entry of the pathogens at the larval feeding sites.

White flies (sent away for identification) have been found in extremely dense populations on cassava for the first time. Cassava supports high numbers of adults as well as immatures. White flies were found at all locations (about eight) surveyed on Mahe. They may be the main vector of a virus-like disease which is inflecting heavy damage on tomatoes (see section below on arthropod vectors of a tomato disease).

In order to expedite collections of mites, a Berlese funnel has been constructed and is now in operation. Mites collected to date are in preservatives and will be sent to acarologists for identification. Every effort is being made to try to encourage continuation of the proper collecting labeling and storage of insects and mites, which are pests as well as beneficial.

b. Identification and control of arthropod vectors of a tomato disease:

One of the most serious pests of tomatoes is a virus-like disease that causes severe stunting of the plants (see report by Contract Plant Pathologist). There is strong suspicion that insects may be vectoring this disease. Earlier experiments involving caging two families of plant sucking insects (Lygaeidae and Myridae) on diseased plants and then removing them to uninfected ones did not demonstrate involvement of these two groups as vectors. Emphasis this quarter has been on investigation of white flies, which occur on tomatoes, as the possible vector.

The white flies occur in very dense populations in cassava. All life stages of this insect were found in abundance. Interestingly, a virus-like disease was often present on the cassava but there is no evidence to show that this disease is the same as that on tomatoes.

A series of experiments were begun in early June and continued through July, involving collecting white flies using an on-line aspirator and transferring them to three different types of cages which were fastened upon diseased branches of tomato plants. After allowing one to three days for the white flies to feed, they were removed to 2.5 ft cubical cages containing uninfected tomato plants. In other experiments, the small screened cages containing the white flies were transferred to

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from infected plants to branches of uninfested tomato plants.

Observations to date reveal no conclusive evidence that the disease has been vectored by the white flies. However, there is some slight stunting, and chlorosis of the leaves on one plant. These plants are currently being monitored and more conclusive evidence should be forthcoming shortly.

These experiments are ongoing and a new set of tests have been designed which utilize smaller tomato plants. This should provide evidence about the relationship between the plant phenology and potential for being infected.

c. Seasonal abundance, distribution and control of fruit flies:

Results of research reported here are part of an ongoing program which was initiated in July, 1981 to determine the seasonal abundance, distribution, relative importance, and control of fruit flies. The experimental design, including trap design and arrangements were described in earlier reports.

Traps at eight locations are checked on a weekly basis and flies are counted and removed. Sex pheromone, insecticides and sticky panels were replaced as needed. Trap sites and type of crop associated therewith are presented below:

| Trap Site | Associated crop (s) |
|---|---|
| Grand Anse Experiment Station | Passion fruit, papaya, other fruits and vegetable crops |
| Souvenir | Passion fruit, some other fruits |
| Farmers Training Center | Passion fruit, tomatoes, other fruits |
| Hermitage | Mainly tomatoes |
| Lafari | Mixed vegetables, especially peppers and tomatoes |
| Jumeau | Citrus |
| SADECO | Peppers, passion fruits, tomatoes |
| Ferrari | Citrus |

In addition to the Trimedlure which was used at all locations, several times during the year the pheromones Cue lure and Methyl eugenol were placed in Steiner traps in the field. These latter two pheromones are effective in attracting fruit flies other than

medflies. Mathyl eugenol attracts the Queensland fruit fly, Dacus tryoni, D. dorsalis, the oriental fruit fly, and several other species of Dacus. Cue lure is effective for trapping the melon fly, D. cucurbitae, and the natal fruit fly, Ceratitis rosa.

The only species of fruit fly found in pheromone traps is the Mediterranean fruit fly, Ceratitis capitata.

In addition to pheromone trapping, fruit fly infested fruits were collected and placed in especially designed trays containing sand. When fruit fly larvae exit the fruit and pupate in the sand, these pupae were removed by a sieve and placed in holding cups. The reason for these collections are two fold: 1) This allows determination of fruit fly species and (2) provides information on the incidence of parasitism To date, only medflies have emerged and no parasites are present. Thus, the medflies were accidentally introduced into the Seychelles without their natural enemies.

Monthly counts of medflies for this quarter (April, May and June) are shown in table 1. Those areas with the highest numbers of medflies were Jumeau and Ferrari. Thus, the highest populations were found in areas with citrus. Lowest populations were recorded in areas where only vegetables were grown. Although medflies have a wide host range, their preference is clearly citrus. During the three month period, denser populations were recorded during May, which coincided with the early ripening of the citrus fruit. In areas such as Grand Anse and Souvenir (with mainly passion fruit), counts increased as the season progressed with highest numbers occurring in June.

Table 1. Monthly counts of medflies caught in traps at eight trapping sites on Mahe during April, May and June 1982.

| TRAP SITE | month of Collection APRIL | MAY | JUNE | TOTALS |
|---|---|---|---|---|
| Grand Anse | 11 | 84 | 606 | 701 |
| Souvenir | 0 | 134 | 248 | 382 |
| Farmer's Training Center | 44 | 48 | 75 | 107 |
| Hermitage | 0 | 288 | 20 | 308 |
| Lafari | 2 | 19 | 8 | 29 |
| Jumeau | 158 | 7,398 | 1,578 | 9,134 |
| SADECO | 0 | 40 | 5 | 45 |
| Ferrari | 171 | 964 | 794 | 1,929 |
| Totals | 386 | 8,975 | 3,334 | |

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Table 2. Total numbers of Medflies per trap at all locations during April, May and June, 1982. Mahe, Seychelles

| Date | Trap Type | | | | |
|---|---|---|---|---|---|
| | Orange | Yellow | Flat White + Dipterex | Flat white + Sticky Panel | Flat white + DDVP resin[1] |
| 7 April | 28 | 22 | 47 | 37 | 34 |
| 14 April | 9 | 2 | 8 | 26 | 49 |
| 21 April | 4 | 9 | 5 | 1 | 18 |
| 27 April | 6 | 3 | 14 | 22 | 19 |
| 5 May | 35 | 175 | 566 | 658 | 263 |
| 12 May | 230 | 857 | 1553 | 915 | 90 |
| 19 May | 176 | 447 | 253 | 61 | 15 |
| 27 May | 615 | 496 | 803 | 703 | 1,076 |
| 2 June | 51 | 145 | 191 | 266 | 471 |
| 9 June | 4 | 41 | 30 | 28 | 147 |
| 16 June | 16 | 90 | 4 | 11 | 37 |
| 23 June | 62 | 42 | 181 | 325 | 396 |
| 30 June | 82 | 64 | 155 | 158 | 322 |
| Totals | 1,318 | 2,393 | 3,810 | 3,231 | 2,937 |

1. Traps with DDVP-resin location only at three locations

A comparison of catches from the five different trap types during April, May and June is shown in table 2. It is obvious that all of the traps are capable of catching medflies [illegible] properly installed and baited with trimedlure. However, during a monitoring-control program, the most efficient trap should be used and this trap should be relatively easily maintained. These data reveal that the color yellow is more attractive to medflies than is orange (2,393 medflies for yellow vs. 1,318 for orange). However, the flat white traps collected more flies than either yellow or orange. The flat white trap containing Dipterex collected the largest number of flies but the differences between these counts and those obtained from the flat white trap with the sticky panel is not significant. On a per trap basis, the flat white trap with the DDVP-resin was most effective. Table 2 shows total numbers collected by each trap type but there were only six traps total (two at each of three locations) as compared to [illegible] for the other types. Further, the DDVP-resin traps were relatively easy to service and avoided the messy substance associated with the sticky panel. Also, there was no need to mix or handle insecticides as was required for the

Dipterex traps. In summary, the DDVP-resin traps were highly effective and will be the trap of choice for the monitoring system in the control part of the program designed for next season.

d. Biological control of the diamond-back moth, Plutella xylostella on cabbage.

Before a biological control program can begin, it is necessary to determine if any natural enemies (namely parasites) are already present. During this quarter, several hundred larvae and pupae of the diamond-back moth have been collected, placed in rearing containers and provided with food until the adult moth emerged.

The purpose of this was to determine if any parasites were present on the larvae or pupae. There were parasite introductions made in 1972 but no follow-up work was done. From data obtained so far, it is not likely that any species which were introduced from the West Indies in 1972, have become established.

The Commonwealth Institute for Biological Control has been contacted and they are willing to send several species of parasites of Plutella. Until we are ready to introduce the species during 1983, periodic collections of Plutella larvae and pupae will be made to make sure that no base-line levels of parasitism exists.

Best Available Document

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Quarterly Progress Report

USAID/SECID CROPS RESEARCH CONTRACT - SEYCHELLES

April, May, June, 1983

Reported by the Contract Entomologist

## INTRODUCTION

The Contract Entomologist was present in the Seychelles from 13 May until 9 July. Although there is a slight overlap into the next reporting period, results of all activities which were carried out between the above dates are reported herein.

Because this was the final period during which the Contract Entomologist was present, certain priorities were re-arranged in order to fill immediate needs and focus upon areas which need additional emphasis. Studies were outlined which can be carried out in the future in the absence of an entomologist. Considerable effort went toward writing a manuscript for publication in the proceedings of the Ninth African Horticultural Symposium to be held in the Seychelles during late July. Also, an oral presentation and visual materials were prepared for this symposium. A seminar was presented to the Seychelles Polytechnic Institute on Integrated Pest Management.

Training Seychellois assistants was emphasized during this period. Topics such as setting up a randomized complete block design, developing sequential sampling models, and pesticide sprayer calibration, received particular attention. Other activities included providing written material for publication in the newspaper, visiting growers' farms and advising growers about insect related problems.

A set of colored slides of the most important insect pests of fruits and vegetables was completed during this reporting period. These will be duplicated and sent to the Grand Anse Agricultural and Food Production Center for using in training, demonstrations, seminars, etc.

Insect and mite surveys were continued and several species have been sent to experts for identification. Identification and control of arthropod vectors of a disease of tomatoes was de-emphasized this period but a program has been developed in conjunction with the Contract Plant Pathologist to further investigate the problem.

Other specific research activities include: 1) insecticide tests for control of a previously unreported cabbage caterpillar, Crocidolomia binotalis, 2) field testing a new spray application system, 3) development of a program for suppression of the Mediterranean Fruit Fly, 4) design of a sequential sampling model for insecticide treatment decisions, and 5) introduction and release of parasites for control of the diamond-back moth, Plutella xylostella.

## RESEARCH ACTIVITIES

Insecticide tests for control of the cabbage worm, Crocidolomia binotalis: This serious insect pest (Crocidolomia binotalis) has not been previously reported as a pest of cabbage in the Seychelles. It is likely that insecticide sprays for Plutella control has been keeping its populations under control. However, in the absence of routine insecticide applications C. binotalis populations reach damaging levels in only 2 to 3 weeks time in some areas.

Damage by Plutella and C. binotalis populations after insecticide treatments are withdrawn is illustrated in Table 1.

Table 1. Damage to cabbage by *Plutella xylostella* and *Crocidolomia binotalis* when no insecticides are applied, Anse Boileau, Mahe, Seychelles, June, 1983 (n = 30).

| Cabbage worm species | Percent of plants damaged | | Percent of plants with larvae | |
|---|---|---|---|---|
| | Field 1 | Field 2 | Field 1 | Field 2 |
| *P. xylostella* | 40 | 13 | 53 | 27 |
| *C. binotalis* | 60 | 33 | 73 | 40 |

The cabbage worm (*C. binotalis*) adult lays eggs in clusters and each plant, in one heavily damaged field, had an average of 16 larvae. Given the critical nature of this problem an experiment was designed to determine the most effective insecticide against this pest.

Larvae of *C. binotalis* were field collected, brought to the laboratory and placed in petri dishes (5 larvae/dish) with cabbage leaves for food. There were seven replicates of each of four treatments. The treatments were: Decis (25 g/liter A.I.), Ambush (500 g/liter A.I.), the microbial insecticide Thuricide (18 g/4000 ml - 1600 IU/mg) and untreated controls. Insecticides were applied with a backpack sprayer to opened petri dishes containing the larvae and cabbage leaves. The sprayer delivered a volume of 24 ml/second and 1.5 seconds were required to spray each set of seven dishes. Dead larvae were counted at the end of 24, 48 and 72 hours. Results from this test are presented in Table 2.

It was clear from these results that all materials tested gave satisfactory control of *C. binotalis*. Control by Decis and Ambush was

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Table 2. Percent mortality of the cabbage worm, Crocidolomia binotalis after insecticide treatments.

| Test period (hours) | Decis (Deltamethrin) | Ambush (Permethrin) | Thuricide[a] (Bacillus thuringiensis) | Control |
|---|---|---|---|---|
| 24 | 64 | 59 | 49 | 0 |
| 48 | 64 | 71 | 62 | 0 |
| 72 | 67 | 71 | 66 | 0 |

[a]Feeding by larvae had stopped by 48 hours.

approximately equal throughout the test period while the effects of Thuricide were somewhat slower. However, control by Thuricide was not significantly different from that for the other materials by the end of 72 hours. The use of Thuricide (or some other formulation of Bacillus thuringiensis) is highly recommended over the other two compounds except in an emergency situation when dense populations of C. binotalis exist. Besides the advantages of being safe and effective, populations of C. binotalis are not likely to become resistant to Bacillus thuringiensis. The use of Thuricide only is recommended in areas where biological control of Plutella using parasites is underway (see section on biological control of Plutella).

Mortality of C. binotalis was not high in this test. This was largely due to the manner in which the insecticides were tested. However, this petri dish test provided good insight into the control potential and relative effectiveness of three compounds. From observa-

tions in the field, it was apparent that insecticide sprays applied for control of Plutella also were controlling C. binotalis.

Field testing a new insecticide application system against the diamond back moth, Plutella xylostella: Several growers complained that they were not getting good control of the diamond-back moth, Plutella xylostella, using Decis. Because Plutella is the major insect pest of cabbage, and insecticide resistance was suspected, a field test was designed to develop more effective means of controlling this insect with insecticides, applied by a backpack sprayer and by a recently-developed ultra low volume Electrodyn sprayer.

The test was carried out on a grower's farm at Anse a la Mouche. The experimental plots were arranged in a randomized complete block design with 20 plants per plot and replicated three times for a total of 60 plants per treatment. Treatments included Ambush (permethrin), Decis (deltamethrin), Thuricide (Bacillus thuringiensis) and an untreated control. In addition to these treatments, samples were taken from different areas of the same field which was treated approximately twice per week by a grower who applied Decis at 1 ml/l of water. Plants in the grower's field were the same variety ('Spring Light') as those in the experimental plots. All plants in the areas were planted the same date and data were taken when the cabbage plants were starting to form heads. Applications of insecticides in the experimental area were made on June 7, on June 9 (because of rain after treatment on June 7) and again on June 14.

The insecticide Ambush was a prepackaged formulation supplied by ICI Americas Inc. It was applied using a new hand-held spray application system (Electrodyn) at a rate of 2.5 ml/plot. The formulation was

a 6 ED (60 g/l A.I.). Decis was applied using a conventional backpack sprayer which delivered a total volume of 1400 ml/100 $ft^2$. Decis was formulated at 5 ml/gal A.I.

The biological control material, Thuricide, also was applied using the backpack sprayer. It was formulated at 18 g/4000 ml. Data were collected on June 21, 1983. Ten plants were selected from each plot and a damage rating, and number of Plutella were recorded from each plant. The damage rating was developed according to the following criteria: 0 = no damage, 1 = slight damage to outer leaves, 2 = moderate damage to outer leaves, 3 = moderate to severe damage to outer and inner leaves, 4 = moderate to severe damage to outer and inner leaves plus some damage to head, 5 = severe damage to head.

In order to determine the distribution of spray droplets by the Electrodyn sprayer, fluorescent uvitex dye was sprayed onto 40 cabbage plants. Then leaves were collected from the tops and bottoms of these plants, and brought to the laboratory for examination under a "black light."

Results from the insecticide test against Plutella populations in the field are summarized in Table 3. The most effective control was achieved using the Electrodyn hand held sprayer. Interestingly, the poorest control was that by the conventional method of a backpack sprayer using Decis, the insecticide most used by growers for Plutella control. Even at two applications per week (grower treated) cabbage plants received significant damage by Plutella. Good control was given by the microbial insecticide Thuricide. This compound is especially effective against young larvae and when applied on a routine basis will result in good control of Plutella throughout the season. Compounds

Table 3. Average damage rating[a] and average number of *Plutella xylostella* on cabbage in response to insecticides. Anse a La Mouche, Mahe, Seychelles, June, 1983.

| Treatment[b] | Mean damage rating | Mean No. *P. xylostella* per plant |
|---|---|---|
| Ambush | 0.67 | 0.27 |
| Thuricide | 0.97 | 1.70 |
| Grower treated[c] | 2.20 | 4.60 |
| Decis | 2.79 | 8.13 |
| Untreated | 4.27 | 8.93 |

[a]Damage rating established according to these criteria: 0 = no damage, 1 = slight damage to outer leaves, 2 = moderate damage to outer leaves, 3 = moderate to severe damage to outer and inner leaves, 4 = moderate to severe damage to outer and inner leaves plus some damage to head, 5 = severe damage to head.

[b]Ambush applied with an Electrodyn hand-held spray system. Other materials applied with a backpack sprayer.

[c]Grower treated with Decis approximately twice per week.

like Ambush could then be used on an emergency basis to bring large populations quickly under control. In addition, by using Decis or Ambush sparingly, build-up of resistance could be greatly diminished and effective control programs could be prolonged.

The hand held Electrodyn spray system is uniquely suited for use on small farms in the Seychelles. The ultra low volume of spray delivered reduces the amount of pesticide that must be transported using the backpack sprayer. The small, charged particles provide excellent coverage of tops and bottoms of leaves. This insures that the spray material is contacted by *Plutella* which often feed on the undersides of leaves.

Insecticides used with the Electrodyn sprayer are premixed and bottled so that the hazards associated with mixing chemicals are eliminated. Application of insecticides using the Electrodyn sprayer took less than one-fifth of the time required for mixing and applying chemicals with the conventional backpack sprayer. The availability and cost of the Electrodyn sprayer is being determined. Proper use of this system could be of tremendous benefit to growers in the Seychelles.

Development of a program for suppression of the Mediterranean Fruit Fly: Extensive surveys which were conducted during the first two years of the project provided baseline information about the seasonal abundance and geographical distribution of the Mediterranean Fruit Fly on Mahe. Additional trapping for other species, using Steiner traps, revealed that only the medfly, *Ceratitis capitata*, was present.

With this background information available, a program was initiated to determine if suppression of the medfly could be carried out in selected areas.

Six areas were chosen and 10 fruit fly traps were located at each site. Each trap was baited with 2-3 drops of trimedlure on a cotton wick and a 3/4" block of DDVP (insecticide impregnated resin). Traps were made from plastic containers described in the last quarterly report. Traps were located from 1-2 meters above the ground. Trapping began on May 18.

The following areas were chosen as trap sites: 1) San Souci, 2) Beoliere, 3) Grand Anse, 4) Les Cannelles, 5) BeauVallon, and 6) Glacis. Each of these areas had a history of infestation by fruit flies.

In order to establish an estimate of the population density in each area, 3 weeks of trapping was conducted before the suppression program

began. The major tactics of the program were based on: 1) monitoring the medfly population using trimedlure in traps, 2) suppression of populations of medfly adults using poison bait sprays, and 3) elimination of medfly breeding sites by removing fallen fruit.

The poison bait sprays, which were used in three target areas (San Souci, Les Cannelles and Beoliere), consisted of a mixture of malathion 50 EC and protein hydrolysate (sold commercially as Staley sauce). The Staley sauce consisted of 240 g/l of amino acids. The resulting spray was made up of 20 grams of protein hydrolysate and 10 grams of malathion per liter. This poison bait spray was applied in "spots" of approximately 100 ml in a grid thoroughout the target areas. Each "spot" was about 15 meters apart. The material was applied to the tips of foliage by backpack sprayers, in areas which were less accessible, and by a motorized tank sprayer.

The suppression program was carried out when populations of medflies are normally most active. This was done in order to test the effectiveness of the suppression program during the period when medflies were at economically damaging levels.

Results from the medfly suppression program are summarized in Table 4. It is clear that there was much fluctuation in medfly pouplation density in treated and in untreated areas. However, mean numbers of medflies per trap per week in the three targeted areas dropped from 25.9 before suppression program began to 6.9 during the 3 weeks after the program was initiated. This contrasts sharply with number of medflies caught for the same periods in the untreated areas which rose from 15.9 during the first 3 weeks of the program to 19.0 for the following 3 weeks.

Table 4. Mean numbers of medflies caught per trap per week in areas treated with poison bait sprays and in untreated areas. Mahe, Seychelles, 1983.

| Location | Sampling date | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Pretreatment | | | | Post-treatment | | | |
| | 25 May | 1 June | 8 June | Means | 14 June | 22 June | 28 June | Means |
| San Souci | 4.0 | 1.4 | 10.2 | 5.2 | 0.9 | 3.7 | 1.7 | 2.1 |
| Beoliere | 55.1 | 8.3 | 53.1 | 38.8 | 15.3 | 32.3 | 1.2 | 16.3 |
| Les Cannelles | 34.6 | 23.3 | 42.8 | 33.6 | 1.5 | 4.8 | 0.4 | 2.2 |
| Overall means | | | | 25.9 | | | | 6.9 |
| | Untreated | | | | | | | |
| Grand Anse | 5.0 | 3.0 | 34.5 | 14.2 | 12.3 | 66.0 | 4.1 | 27.5 |
| Beau Vallon | 33.7 | 14.8 | 27.8 | 25.4 | 7.5 | 42.7 | 22.9 | 24.3 |
| Glacis | 10.4 | 4.6 | 9.3 | 8.1 | 2.2 | 4.7 | 8.7 | 5.2 |
| Overall means | | | | 15.9 | | | | 19.0 |

There is little doubt that rainfall, which occurred intermittently throughout the program, reduced the effectiveness of the poison bait sprays. This would account for the increases in the numbers of medflies caught after some treatments were applied. However, in general, there was an overall greater reduction in the density of medflies in areas where the suppression program was being carried out. On a practical basis, a grower could achieve significant reduction in numbers of damaged fruit by weekly applications of the poison sprays during the period between May through July, combined with a rigorous program of sanitation (removal and destruction of fallen fruit). The grower could re-apply the poison bait after rains and thereby insure better control.

Design of a sequential sampling model for insecticide treatment decisions: In order to develop sound pest management programs, the use of sequential sampling for insecticide treatment decisions has become increasingly popular. In Seychelles, where insecticides are applied on a schedule basis, there is a particular need for the application of sequential sampling methodology. There are several advantages to the use of this approach for making treatment decisions. Firstly, there is normally a substantial savings in the numbers of insecticide applications that are needed; secondly, this reduces the overall cost of a control program and avoids the attendant side effects (health hazards, effects on non-target species, resistance, etc.) of routine insecticide applications for attempted control of an insect which may or may not be present.

The following is an example of development of a sequential sampling model for the diamond-back moth (*Plutella*) on cabbage. The program was

written for a hand-held TI-59 calculator, and a magnetic card containing the program and instructions for program execution were provided.

There are three essential pieces of information needed for development of a sequential sampling plan: 1) the insects' distribution in the field (for Plutella, this distribution was described by a Poisson), 2) the level of risk that the grower (or sampler) is willing to take (for most cases, 90% probability of being correct is sufficient), and 3) the damage threshold (for Putella, these values are set at a very conservative level, e.g. if 2-3 plants out of 10 contain Plutella larvae, an insecticide treatment is necessary).

The formulas for developing the sequential model are as follows:

$$d_1 = b_n - h_1 \text{ (lower decision line)}$$

$$d_2 = b_n + h_2 \text{ (upper decision line)}$$

$$\text{where } b = \frac{M_2 - M_1}{\text{Log } M_2 - \text{Log } M_1} \qquad h_1 = \frac{\text{Log } \frac{1-\alpha}{\beta}}{\text{Log } M_2 - \text{Log } M_1} \qquad h_2 = \frac{\text{Log } \frac{1-\beta}{\alpha}}{\text{Log } M_2 - \text{Log } M_1}$$

Where $M_1$ = 2 (or two larvae present out of a 10-plant sample (n)),

$M_2$ = 3 (or three larvae present out of a 10-plant sample)

$\alpha$ and $\beta$ are the risk levels (set at 0.1)

The major objective is calculation of the values of $h_1$, and $h_2$, which are needed for developing tables or decision lines.

For the example of Plutella, the following table was developed. Although threshold values for Plutella are largely subjective, this plan (Table 5) should provide a point of departure for testing the model in the field.

Table 5. A sequential sampling plan for Plutella on cabbage in Seychelles.

| No. of 10-plant samples (n) | | No. of larvae found: Lower limits ($h_1$) | | Upper limits ($h_2$) | |
|---|---|---|---|---|---|
| 2 | | < 1 | | > 11 | |
| 3 | | < 2 | | > 13 | |
| 4 | do not | < 5 | continue | > 16 | treat |
| 5 | treat | < 7 | sampling | > 18 | |
| 6 | | <10 | | > 21 | |
| 7 | | <12 | | > 23 | |

Recommendations for testing the sequential plan include sampling a field (or plot) of cabbage and making treatment decisions based on Table 5. A companion grower's field should be used to test the usefulness of the model. Comparisons between the two areas should include: 1) number of insecticide applications to each field, 2) amount of time spent spraying, 3) amount of time spent sampling, 4) overall costs for spraying and scouting, and 5) resulting yields or marketable produce from each field.

Although the sequential sampling plan for Plutella has not been tested in the Seychelles, inputs used to develop the model are based on reliable information from other areas of the world. Sequential plans have been an extremely useful tool for making pest management decisions. Plans have been made for testing this model in the coming months.

Introduction and release of parasites for control of the diamondback moth, Plutella xylostella, on cabbage: For the past 2 years larvae and pupae of Plutella have been collected in order to determine if any

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parasites of this pest exist in the Seychelles. Results from these collections reveal that Plutella is virtually free of parasites. With this background information, a program of parasite introductions was organized with the Commonwealth Institute of Biological Control.

Two areas were targeted for parasite release sites - untreated cabbage plots at Grand Anse and Anse Boileau. These areas were planted to cabbage before the Contract Entomologist arrived to insure populations of Plutella. Additional plantings of cabbage, at the same sites, were made to help insure adequate host populations for establishment of the introduced parasites. Three species of Plutella parasites have been released in the two areas: 1) Diadegma sp., 2) Diadromus (Thyraeella) collaris, and 3) Apanteles plutellae. Numbers and species of parasites released in the two areas are listed in Table 6. Before parasites were released in the field, they were held in the laboratory to insure that no hyperparasites were present.

Results from collections of Plutella larvae and pupae are very encouraging. Although only about 100 larvae and pupae have been collected from the parasite release sites, 9 Diadegma sp. have been recovered. This is a good indication that species is establishing itself in the field. The incidence of parasitism is expected to increase in these areas provided application of chemical insecticides can be avoided.

The following approach is recommended for expansion of the biological control program against Plutella: weekly collections of Plutella larvae and pupae from release sites should be continued in order to monitor the incidence of parasitism. Plutella larvae and pupae should be held in the laboratory until parasites, if any are present, emerge.

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Table 6. Number and species of parasites received from the Commonwealth Institute of Biological Control - Pakistan Station, and released on Mahe, Seychelles, for control of *Plutella xylostella*. 1983.

| Shipment No. | Date released | Number released | Species released | Place released |
|---|---|---|---|---|
| 1 | June 6 | 23 | *Diadegma* sp. | Grand Anse |
| | June 6 | 10 | *Diadromus* (*Thyraeella*) *collaris* | Grand Anse |
| | June 7 | 18 | *Diadegma* sp. | Anse Boileau |
| | June 7 | 8 | *Diadromus collaris* | Anse Boileau |
| 2 | June 17 | 53 | *Apanteles plutellae* | Grand Anse |
| | June 17 | 32 | *Diadegma* sp. | Grand Anse |
| | June 19 | 18 | *Apanteles plutellae* | Anse Boileau |
| | June 19 | 73 | *Diadegma* sp. | Anse Boileau |
| 3 | June 24 | 60 | *Diadegma* sp. | Grand Anse |
| | June 24 | 28 | *Diadromus collaris* | Grand Anse |
| | June 26 | 10 | *Diadegma* sp. | Anse Boileau |
| | June 26 | 25 | *Diadromus collaris* | Anse Boileau |
| | June 27 | 7 | *Diadegma* sp. | Grand Anse |
| | June 27 | 15 | *Diadromus collaris* | Grand Anse |
| | June 28 | 3 | *Diadegma* sp. | Grand Anse |
| | June 28 | 5 | *Diadromus collaris* | Grand Anse |
| 4 | July 1 | 23 | *Diadegma* sp. | Grand Anse |
| | July 2 | 23 | *Diadegma* sp. | Anse Boileau |
| | July 5 | 18 | *Diadegma* sp. | Grand Anse |

These should then be identified and released back into the untreated cabbage fields. A record should be kept of numbers of Plutella larvae and pupae collected, numbers of adult Plutella which emerge, numbers and species of parasites which emerge.

Plantings of cabbages should continue in the untreated areas in order to insure that adequate host populations are available for the parasites to attack. After 4 to 6 months, generations of these parasites should be at a level where substantial control of Plutella is being realized. At this time, a small plot on a grower's farm should be designated for releases of Plutella. It should be realized that if insecticides are withdrawn from this plot, substantial damage will be caused by the rapid "resurgence" of Plutella. The grower's plot should be replanted with cabbages as necessary and releases of Plutella parasites should be made as soon as insecticide treatments cease. Areas adjacent to the designated release site should be treated only with Thuricide (Bacillus thuringiensis).

When parasites are available from collections made from the original release sites, they can be transferred to the grower's plot. Additonal parasites can be obtained from:

Dr. A. I. Mohyuddin, Entomologist-in-charge
Commonwealth Institute of Biological Control
Pakistan Station
P. O. Box 8
Rawalpindi, Pakistan

After parasites are established on the grower's plot, and are controlling Plutella, the areas can be gradually expanded. Later in the program, several farms can be included using the same approach as above.

Control of Plutella using parasites has been achieved in Barbados and Zambia. With careful planning and execution of this program, biological control of Plutella using parasites and occasionally Thuricide should be successful in the Seychelles.

APPENDIX 5: Dr. Garnet Craddock's End of Tour Report

TERMINAL REPORT FOR

SCIENTIST SEGMENT OF USAID/SECID

FOOD CROPS IMPROVEMENT CONTRACT

WITH MINISTRY NATIONAL DEVELOPMENT

REPUBLIC OF SEYCHELLES

INTRODUCTION: A total of fourteen months of soil scientist time was budgeted for the Food Crops Research Contract. Initially, the soil scientist was scheduled to be in resident during the first twelve months of the project and later make two return visits of one month each time.

In actuality, the time spent in the Seychelles by the contract soil scientists was modified because of delays encountered in procuring equipment and supplies for the laboratory and the training of the Seychellois counterpart. Thomas Cochrane initial contract soil scientist, was in Seychelles from mid July 1981 through February 1982, and again July 1983 through September 9 1983. Garnet Craddock was appointed Contract soil scientist and was in the Seychelles during the period September 1, 1983 through March 31, 1984. In addition, he was appointed acting Chief of Party September 7, 1983 and later Chief of Party until the project terminated March 31, 1984.

A. Soil Test Facility: The most critical part of implementing a soil scientist's program is that of establishing a useful soil and plant analytical facility. Because the original equipment ordered for this facility was found inappropriate and chemical reagents were not supplied, soil analyses could not be carried out during the first year of the contract. Reagents and equipment had to be reordered. This required

considerable time because of shipment to the Seychelles. Further in late December 1981, Grand Anse Agriculture Centre was assured that funds would be available for the construction of a modest independent plant and soil diagnostic laboratory complex by remodelling of a building to be turned over to the centre in early 1982. Assumption was made that the facility would be completed by late 1982. In actuality the laboratory was virtually completed in July 1983 and became operational for some routine testing in December 1983 and finally fully operational in February 1984. In the anticipation of the events above, the soil scientist contract time in the Seychelles was modified. Accomplishments in some areas were enhanced by the modified schedule whereas in other areas accomplishments were no doubt adversely affected.

The following information is provided to give an insight to the overall accomplishments of the Food Crops Project in relation to the specific goals outlined.

B. <u>On-the-job-training and supervision of a full-time counterpart technician in researching options for maximizing soil fertility to increase on-farms production</u>: A technician, Mr. Waven Williams was assigned to assist the soil scientist at the very beginning of the project. During periods when no soil scientists were present this technician was under the supervision of the Chief of Party, the contract horticulturist. Until late August 1983, this technician was taught to follow LaMotte quick test procedures for soil analyses. Although many soil analyses were made, there was a void of plant

growth response. Therefore all users of soil test results were advised to use caution in interpretation. In addition to being trained as a laboratory technician, Mr. Williams was given the opportunity to assist in field plot trials to broaden his experience. Beginning in July 1982, the project sponsored a six week short course to give additional training for Mr. Williams and two other technicians in the U.S.A. For four weeks, Mr. Williams participated in ongoing research projects and soil testing activities at Clemson University. He was able to participate in a soil testing laboratory where some 80,000 soil samples are processed on a yearly basis. Unfortunately, in late August 1983, Mr. Williams resigned from the technician position and assumed a position with the Island Development Corporation stationed on Coetivy.

Mr. Jose Lalanne was hired in the technician position beginning September 1, 1983. Since that time he was taught to carry out routine soil testing by the LaMotte procedures but more importantly how to carry out soil testing by more refined procedures that are recognized worldwide. In addition, he has been given instructions in how to carry out pot culture fertility experiments as well as some experience in conducting field experiments in corporation with the Plant Pathology program.

On October 15, 1983, Mr. Antoine Moustache returned to Seychelles from the University of BWI, Trinidad where he received the B.S. degree in general agriculture. Immediately, he was assigned as the counterpart to the soil scientist as an agricultural official. His training to date has been in

the area of how to follow and carry out acceptable soil testing and plant analyses procedures, how to work independently but corporatively with other officials and technical help, how to use soil test and plant analyses data to formulate fertilizer recommendations for various crops and how to use research technicians to accumulate data to solve problems.

In the brief period October 15, 1983 through March 31, 1985, Mr. Moustache has performed beyond expectations. He is fully capable of organizing and carrying out all procedural aspects which are required in a modest modern soil test and plant analyses laboratory. For the last three months, January through March, he has assumed responsibility for making all fertilizer recommendations based on soil test data. Admittedly, these recommendations are still in need of refinement as additional soil fertility research data are needed for correlation purposes.

Additionally, Mr. Moustache has presented radio broadcast programs relating to soil fertility and has actively participated in writing soil fertility information for the Nation (Seychelles Newspaper). He contributed greatly in the fertilizer recommendation guide and the mimeographed soil analyses procedure outline for the Seychelles.

In assisting in the conduction of a pot fertilizer experiment with maize he has received some training in research techniques. Unfortunately, there has been insufficient time to initiate and carry through field research.

C. Assist in the conduction of a general survey of soil fertility levels in different locations on Mahe, Praslin and La Digue

Throughout the period July 1981 through March 31, 1984, several hundred soil samples have been taken and analyzed. In 1982 some fifty soil samples were sent to Clemson University with requests of physical and chemical tests. Analyses were made and results were returned to Seychelles in July 1982. This information has been helpful in evaluating technique at the Seychelles laboratory and for general assessment of soil conditions on Mahe.

In December 1983, Moustache and Craddock took numerous samples of soil on Praslin and La Digue from fields with and without known fertility problems. These samples were largely used to establish which extraction procedures that would be followed in the Seychelles.

With confidence several statements can be made about Seychelles Soils. The red soils or red earths (Piggott) are quite acid. These uncultivated soils are very acid and require wood ashes or a liming material to correct acidity. They are initially very low in available phosphorus and low in Potassium. Also the practice of using composts and a complete fertilizer is essential for food crop production.

Coralline soils can be classified into two categories - the coralline sands on flat lands of the granite islands and outer islands low in Calcium phosphates, and the coralline sands on flat lands that have high levels of calcium phosphate.

(usually pressence of guano). These soils have a very high pH (7.9-8.2) and usually will be very low in most of the fertilizer elements except Ca. Response to P will be dependent upon amount of available present. Micro nutrients will generally be a serious problem. Therefore crops will generally respond to sprays containing Fe, Mn, B, Cu, and Zn. Use of manure and composts are essential if cultivated crops are to be grown intensively.

Nitrogen is recognized as being very low in almost all soils except where deposits of organic matter are found.

D. Development of a classification system for the soils of Seychelles

Cochrane, the initial soil scientist for the project, has presented a good discussion on soils of Seychelles in the October - December 1981 quarterly report. The suggestion is made that five very different soils occur in the Seychelles and in general fall into the following categories.

The Red Earth Soils:

The term Red Earths has been applied to most of the granite-derived soils in the Islands of Mahe and Praslin; these cover by far the greatest acreage of lands. In soil classification terminology according to Soil Taxonomy (1976), these would classify as Oxisols at the Order level, both Udox and Ustox at the Sub-Order level and would separate into a progressively wider range of "soils" down the several categorical levels of that system. Consequently, to group such soils under the heading Red Earths - or even to use the erosion phase separation of Piggot (1968) is a gross over-simplication. Nevertheless,

simplification may be desirable if it is possible to use such terminology for practical purposes, especially the development of a more viable fertilizer policy. A general group of problems appear common to these soils.

a) Potential erosion problems - a site specific factor

b) Low soil moisture holding capacities. Low soil moisture holding capacities are common in Oxisols in-spite of the presence of moderate amounts of clay. The micro-structure of these soils is such that it often gives them moisture holding capacities approaching those of sands.

c) Soil acidity - Potential Aluminium toxicity problems for some crops, and low availability of Molybdenum, and possibly Boron, generally.

d) Macro-element problems. The soils often have very low levels of Nitrogen, Phosphorus and Potash.

e) Minor element problems. Calcium and Magnesium levels are low and Sulphur levels may well prove limiting.

In a positive soil management sense, the phosphorus deficiency problem of these soils may be over-come by using locally produced Guano. Being acid, they virtually act in the same way as a super-phosphate factory, converting the relatively unavailable phosphorus in Guano to a form more readily assimilable by plants. As a first approximation for developing a more economical fertilizer policy for these soils therefore, guano should be accorded top priority.

Soil acidity problems might be over-come by the strategic use of liming in addition to the current practices of using wood ashes by taking into account the total amount of liming materials being applied in fertilization, including the calcium content of guano and the use of other calcium containing materials. Cochrane

et al. (1981) have shown how minimal lime requirements can best be calculated. If further liming is needed, this could be supplied by using ground limestone.

Apart from Limestone Ammonium Nitrate, Urea could be used as a nitrogenous fertilizer on these soils. Potassium nitrate may be also a potash source. Ammonium sulphate should only be used sparingly, as it will quickly acidify the soils.

For intensive horticultural and food crop production, the incorporation into the soils of organic matter such as composts, farm yard manure and chicken litter is an established practice that should be encouraged as it helps improve soils both chemically and physically.

2. The Shioya Series (Coralline sand) soils of outer coral islands

The "label" on problems likely to be encountered, and their possible solutions especially in terms of manurial practices for this second most important group of soils, is radically different from that of the Red Earth Soils. The problems may be listed as follows;

a) Extremely low soil moisture holding capacities

b) Very high calcium carbonate contents

c) Low macro-element contents, particularly potash and nitrogen

d) Dubious availability of minor elements including magnesium and sulphur.

e) Obvious and often spectacular deficiencies of micro-elements including iron, maganese and possibly Zinc. Other micro-elements including Cu and B may also prove deficient.

f) Disparity in the amount of available phosphorus present. The amount of available phosphorus will be dependent upon the

Perhaps the only positive thing that can be said about these soils is that, at least in their upper horizons, soil salinity problems do not appear to compound those of excess calcium carbonates to any great degree. Nevertheless, chloride toxicity problems have been seen to occur in soils located near the sea (see memo attached), and where possible, high chloride fertilizers such as muriate of potash (potassium chloride) should be avoided.

In attempting to manage these soils, particularly for intensive horticultural crops, the use of irrigation would appear paramount. Drip irrigation would be preferable to sprinkle. Furrow irrigation would be out of the question. As much organic matter as possible should be incorporated to help moisture and nutrient holding capacity.

In so far as their chemistry is concerned, there are undoubtedly considerable benefits to be obtained from acidifying these soils, even slightly. Sulphur might be used, together with the continued use of acidic , nitrogen supplying fertilizers. Alternatively, acidic peat (see memo to Mr. M. La Farrie) might be added, or even Red Earth soils mixed with the sands to completely change their properties.

The use of ammonia based nitrogenous fertilizers especially sulphate of ammonia, is often cited as a poor practice on calcareous soils. High pH encourages the liberation of ammonia gas and consequent losses of nitrogen. However, this will only occur if sulphate of ammonia is applied to the surface of the soil. If it is applied as a band in a small (at least 5 cm deep) furrow and covered over, and particularly under drip irrigation, there is no reason to expect significant losses in nitrogen. In fact,

useful side effects, by making limiting micro-nutrients more available.

In contradiction to Varley (1971) the soil Scientist would not recommend the use of urea for these soils as a source of nitrogen. In high pH soils, urea often produces a temporary (4 to 6 week) significant increase in pH. This can induce manganese and zinc deficiencies and aggravate iron deficiency.

Ammonium nitrate might be used safely on these soils. However, this fertilizer, unless treated with lime as limestone ammonium nitrate, is probably too hygroscopic for storing any length of time in the Seychelles.

Potassium nitrate could be used as a source of both nitrogen and chloride-free potash for intensive horticultural production. Potassium sulphate is another satisfactory source of potash.

Additional magnesium as magnesium sulphate, may be needed on many calcareous soils. To overcome trace element problems, iron, manganese and zinc would have to be applied either to the soil as sulphate or directly to the plant leaves either as sulphates or chelates.

3. <u>The Shioya Series</u> (coraline sand) soils on coast of granite island

Most managerial practices will be the same for these soils as the sands of the outer islands except available phosphorus will be usually very low.

4. <u>Alluvial soils along streams</u>

Alluvial soils along streams of the granite islands may occur in very small areas but can be highly productive if managed to protect flooding. These soils generally will be higher in available

nutrients and organic matter than the surrounding soils.

5. Marsh or peat soils

Very poorly drained soils in flat areas near the coast may have a very high percentage of organic matter and humus. In general these areas are too wet for cultivated crops, exceptions being those crops tolerant of free water.

The soil scientist sampled some fifty different sites on Mahe during the first work period. Soil samples from these sites were analyzed for physical and chemical characteristics by Clemson University and the results are on file in the Soil and Plant Diagnostic laboratory.

E. Calibrate soil testing and undertake plant testing for various food crops growing in different soils

Several soil testing procedures were considered and used on some fifty different soils to arrive at standard methods to be used in the Plant and Soil Diagnostic laboratory for red and coralline soils. The double acid extraction procedure was found to be most satisfactory of all methods tried for phosphorus for both coralline and red soils. Sodium bicarbonate methods were tried with little success for coralline soils. The double acid method was found to be as satisfactory as other methods for cations. Currently the double acid (.05NHCl + .02N $H_2SO_4$) is being used as the standard extractant for P, K, Ca, Mg, Fe, Zn, Mn, and Cu. Refer to the mimeographed "soil testing procedures used in the Seychelles" for methodology followed.

To date very little correlation data are available to make recommendations based on soil test. Tentatively, fertilizer recommendations are being made with reference to soil test values now being used at Clemson and Auburn Universities. In time, these soil test values will need to be refined to Seychelles soil conditions for the production of fruit, vegetable and nut crops.

F. Improved farming practices as related to soil management with emphasis on proper use of chemical and organic fertilizers

A review of fertilization practices was made by searching through available publications on food production in the tropics and in particular, Seychelles. Current methods were critically evaluated. As a result, a tentative fertilizer guide for Seychelles crops was prepared. It is anticipated that this document will be revised from time to time as additional experience and data become available.

A guide was provided to the Grand Anse Experiment Station relating to mixtures of soil materials and compost that should be used for nursery plantings.

G. Participation in demonstrations, lectures etc.

The soil scientist assisted the horticultural and plant pathologist in suggestion of fertilization practices to be followed for the regional trials and other plantings. Several trips were made to various parastatal, corperative farms and private farms to access general plant nutritional condition of growing crops. Often problems of micro nutrients deficiencies were noted on coralline soils.

A paper was read before the International Society for Horticultural Science at the Ninth Africa Horticultural Symposium in Seychelles on the Evapotranspiration. Its influence on natural vegetation patterns and importance to crop introductions.

H. Preparation of bulletin on methods of increasing soil fertility

A fertilizer guide intended for the use of farmers in the production of vegetables, fruits and nuts was prepared.

Newspaper articles were prepared for use in the Nation relating to soils and their management, and fertilization practices.

I. Assist GAC in establishing a technical library in Agronomy, soil science, general and analytical chemistry and organic farming

Approximately twenty books were purchased or donated for use by the agricultural staff on agronomy, chemistry and soil testing methodology. In addition several reprints of published articles were secured for in depth use.

APPENDIX 6: Laboratory Procedures and Fertilizer Recommendations

METHODS USED FOR ROUTINE SOILS ANALYSES IN SEYCHELLES

MARCH 1984

LaMotte Quick Test procedures can be used for soil testing with caution whenever nore sophisticated equipment or methodology is not available. Some effort was made in this laboratory to relate LaMotte results to more reliable procedures with very limited success. Advantage of LaMotte procedure is that methods used are mainly colorimetric or turbidometric and reagents are already prepared. Disadvantage of LaMotte is that results are very arbitrary and correlation of results between LaMotte and more sophisticated methods are not available. The LaMotte phosphorus and nitrogen test results are difficult to interpret.

SAMPLE PREPARATION

Results of soil tests can be of use only if the soil sample is representative of the plot or field from which the sample is taken. Use of accepted procedures for collecting is mandatory, if results are to be reliable. A composite sample in the amount of two pints or 500 cc is adequate for all soil tests.

Soil samples are dried at 40°C for 48 hours, then ground to pass through a B.S. No. 8 mesh sieve. The sieved soil is mixed and carefully subsampled for the various analyses. If the soil is suspected (light in color) of being coralline a free carbonate test is made on a subsample by use of a 30% HCl solution; liberation of $CO_2$ indicates the presence of free carbonates. Soils that show the presence of free carbonates are further analyzed for electrical conductivity to determine if they are saline or calcareous.

1. ELECTRICAL CONDUCTIVITY

Soils are classified on the basis of the preliminary analysis as follows:

| Conductivity milli mhos/cm | Free $CaCO_3$ | Classification |
|---|---|---|
| Less than .400 | absent | Non Calcareous, non saline |
| Less than .400 | Present | Calcareous, non saline |
| Greater than .400 | Absent | Non calcareous, saline |
| Greater than .400 | Present | Calcareous, saline |

Soluble salt reading in mmho/cm and corresponding ppm of salt in 1:2 air-dried soil (volume to volume) water extract and salinity effects on plant growth.

| Reading MMho/cm | Salt ppm | Salinity Effects | |
|---|---|---|---|
| 0.40 | 512 | Salinity effect not important | |
| 0.40 - 0.80 | 512-1024 | Very slightly saline | Low salt tolerant plants affected |
| 0.81 - 1.60 | 1025-2048 | Slightly saline | Medium salt tolerant plants affected |
| 1.61 - 2.40 | 2049-3072 | Moderately saline | Fruit crops affected |
| 2.41 - 3.20 | 3073-4096 | Strongly saline | Only highly salt-tolerant crops give satisfactory yields. |
| 3.20 | 4096 | Very strongly saline | Only a few high salt tolerant plants grow. |

PROCEDURE

25 gms of No. 8 mesh sieved soil are added to 50 ml of deionized water and shaken for 30 minutes. The suspension is then read for condictivity in milli mhos per cm.

2. CALCIUM CARBONATE DETERMINATION

Calcium carbonate determinations are carried out on 1 gm of B.S. No. 60 mesh sieved soil. A "Collins Calcimeter," or some other means is used. Titration is a good option, but it is slow and the end point cannot be determined readily unless soil is finely ground.

3. SOIL pH

The pH of a soil-water suspension depends on the ratio of soil to water. It is necessary to use a standardized procedure. The soil to water ratio of 1 to 2.5 is used.

PROCEDURE

20 grams of B.S. No. 8 mesh sieved soil are added to 50 ml of deionized water, stirred with a glass rod and allowed to stand for 1 hour. Soil is stirred again and read to one decimal place using a pH meter.

Before reading each set of samples, standardize the pH meter against two known buffer solutions having values of 4.00 and 6.00 respectively. Occasionally use a reference soil having a known pH. This value should be used as a check on instrument accuracy and proper functioning.

4. LIME REQUIREMENT (BUFFER pH)

Red soils are usually quite acid and if pH is to be adjusted to near neutrality (pH 6.5) both buffer pH and water pH are measured to determine the amount of $CaCO_3$ equivalent liming material that will be needed.

Reagent:

Dissolve 540g of $Ca(C_2H_3O_2)_2$ in approximately 5 liters of distilled water. Add 33.7 ml of triethanolamine, dilute to 9 liters with distilled water, and mix thoroughly. The pH of the solution should be 9.6. Fit the bottle with a delivery tube and protect the solution from atmospheric

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$CO_2$ by covering with mineral oil.

Procedure:

Place 10 grams of soil in a 50 ml beaker and add 50 ml of the buffer solution. Stir intermittently until the pH of the blank is 9.3 (approximately 4 hours). Stir thoroughly and measure the pH of the soil-buffer suspension with a glass electrode.

5. EXTRACTING SOLUTIONS FOR AVAILABLE NUTRIENTS

Extracting solutions may be different for red (oxisols) and coralline soils. The North Carolina solution (0.05N HCl plus 0.025N $H_2SO_4$) is used for mainly Acid soils (1, 2). The Bray No. 2 (0.03N $NH_4F$ plus 0.1N HCl) is usually satisfactory for soils that have free carbonates and a pH of 7. A modified Olsen method may be preferable for soils with a pH above 7.

Preparation

A. Mehlich No. 1 - (0.05N HCl plus 0.025N $H_2SO_4$) - Add separately 40.5 ml of concentrated HCl and 7.0 ml of concentrated $H_2SO_4$ to approximately 5 liters of distilled $H_2O$. Bring the volume to 10 liters.

B. Bray No. 2 (0.03N $NH_4F$ and 0.1N HCl - Dissolve first 37 gm $NH_4F$ in distilled water and bring to 1 liter volume This is 1.0N $NH_4F$ and should be stored in a polyethylene bottle. Add 165.6 ml of concentrated HCl to about 500 ml of distilled water and bring to volume of 1 liter. The extracting solution is made by adding 30 ml of 1.0N $NH_4F$ and 50 ml of 2.0N HCL to about 500 ml distilled water and brought to a volume of 1 liter.

Note: If filtering is slow when either the N.C. or Bray extracting solutions is used then 1 gram of Superflock 127 per 10 liters of extracting solution can be used. (Probably not needed for sands).

C. Modified Olsen Method - 5 gms of B.S No. 8 Mesh sieved soil are shaken for 15 minutes with 50 ml of 0.5M sodium bicarbonate solution and a teaspoonful of sodium bicarbonate-washed "Dacco G. 60 Activated Carbon" (3). The suspension is filtered thru Whatman No. 42 filter paper. To determine the phosphorus content on the filtrate, a modification of the Watanabe and Olsen ascorbic acid method is used.

A solution containing 1.0 gm of ammonium molybdate, 0.024 gms of potassium antimony tartrate and 20 ml. of conc. sulphuric acid per liter is prepared and stored in a dark place. Prior to using it, add 1.0 gm of ascorbic acid per liter. A 20 ml aliquot of the latter solution is added to a 5 ml aliquot of the filtrate. Maximum color development occurs within 20 minutes. The color intensity is read against phosphorus standard. (An EEL absortiometer using 4 cm light path cells and the No. 608 filter was used).

Extracting Procedures

Measure a scoop (approximately 5 grams) of soil into an extraction container. (Volume of 5 ml is preferable to 5 gms). Add 25 ml of extracting solution to soil and shake for 5 minutes. Filter immediately through a Whatman #2 or equivalent filter paper. Aliquots are taken from this extract for P, K, Ca, Mg and other ions.

6. PHOSPHORUS

Standard Stock Solution: Dissolve 0.4392 g of dried C.P. $KH_2PO_4$ in 1 liter of extracting solution. This solution contains 100 ppm of P.

Working Solutions: Pipet 0, 5, 10, 15, 20, 30, 40, 50 and

60 ml of the stock solution into 100 ml volumetric flasks. Make to volume. The standards are equivalent to 0, 5, 10, 15, 20, 30, 50 and 60 ppm of P in the soil.

Reagents

#1. Ammonium Molybdate - Antimony Potassium Tartrate: Dissolve 100 g of ammonium molybdate in approximately 500 ml of distilled $H_2O$ in a 2-liter volumetric flask. Dissolve 2.425 g of antimony potassium tartrate in the molybdate solution. Add 250 ml of concentrated $H_2SO_4$, cool, and make to volume with distilled $H_2O$. Store in refrigerator.

#2. Color Reagent - ascorbid Acid and Reagent #1: Depending upon the number of samples, mix the ascorbic acid, reagent #1, and extracting solution in the following proportions.

| Number of Samples | Ascorbic Acid | Reagent #1 | Extracting Solutio |
|---|---|---|---|
| 15 | 0.22 grams | 5 ml | 245 ml |
| 30 | 0.44 grams | 10 ml | 490 ml |
| 60 | 0.88 grams | 20 ml | 980 ml |
| 120 ml | 1.76 grams | 40 ml | 1960 ml |

The color reagent is prepared the day before it is to be used or at least two hours before it is to be used. The color reagent cannot be used after 24 hours.

Use a dilutor

1. Add 2 ml of the soil extract (or standards) to a glass cuvette then add 3 ml of deionized water to the extract and 12 ml of reagent. Allow color to develop for a minimum of 30 minutes. Prepare daily a standard curve from the P standards as described above.

Adjust the spectrophometer with the 0 and 60 ppm standards at 882 nm, so that the percent transmission reads the same as the standard curve.

7. Determination of potassium, calcium and magnesium, and sodium by Mehlich I (0.05N HCl in 0.02N $H_2SO_4$) Extractant.

Potassium, calcium, magnesium, sodium, zinc and manganese can be extracted and determined in soil concentrations from 50 to 400 kg/ha for K, 120 to 1200 kg/ha for Ca, and 40 to 360 Kg/ha for Mg without dilution.

Interferences

The use of internal standards such as lithium or compensating elements such as lanthanum are essential in most flame methods of excitation.

(a) Potassium

Standard Stock Solution: Dissolve 0.6961g of dried $KH_2PO_4$ (28.73%K) in 1 liter of extracting solution. This solution contains 200.00 ppm K.

Standard Working Solutions: Pipet 0, 2.5, 5.0, 7.5, 10.0, 12.5, and 15.0 ml of the 200 ppm K solution into 100 ml volumetric flasks. Make to volume with extracting solution and mix thoroughly. The standards have the concentrations of 0, 5, 10.0, 15.0, 20.0, 25, 30 ppm of K. However soil samples will have the following concentration of K), 25, 50, 75, 100, 125, 150 ppm (multiply standards times 5 for dilution factor). Potassium by flame emission is generally more accurate and less costly to run than by atomic adsorption.

(b) Magnesium

Standard Solutions: Add 1g of Mg ribbon to a 1 liter volumetric flask. Dissolve the Mg in 20 ml of 1:4 HCl

and dilute to 1 liter with extracting solution. This solutions contains 1000 ppm Mg. If Mg ribbon is not available use a pure non-hygroscopic salt. Dilute 25 ml of the 1000 pm Mg solution to 1 liter to give a 25 ppm Mg solution. Pipet 0, 10, 15, 25, 35, 40 and 50 ml of the dilute stock solution into 100 ml volumetric flasks. Add 10 ml of 1.0% lanthanum in 5% HCl. Make to volume with extracting solution. Standards are equivalent to 0, 10, 15, 25, 35, 40 and 50 ppm of magnesium in the soil (1:4 soil-extracting ratio).

Turn on the AA Spectrophotometer and allow to warm up. Adjust air and gas to recommended pressure of 150 KPa and 50 KPa respectively and light the burner.

1. Atomize the 0 standard and adjust the absorption to read 0 with Abs dial.
2. Atomize the 50 ppm standard.
3. Recheck
4. Atomize an intermediate standard to see if points are falling on the curve.
5. Atomize samples and record readings. Convert readings to ppm Mg.

(c) <u>Calcium</u>

Dissolve 2.5g of $CaCO_3$ in 1:HCl (just enough to get into solution) and make to a liter with distilled $H_2O$ to make a 1000 ppm Ca standard. Pipet 0, 5, 10, 15, 20, 30, 40 and 50 ml of the 1000 ppm solution into a series of 200 ml volumetric flasks. Add 10 ml of 1.0% lanthanum in 5% HCl and make to volume with extracting solution.

Unknowns or sample extracts should have the equivalent of 1:1 of sample extract plus water to 1.0% lanthanum) 102

Turn on the atomic absorption spectrophotometer and allow to warm up. Adjust air and gas to appropriate levels and peak instrument with cathode ray tube for calcium at 422-7 wave length.

1. Atomize the 0 standard and adjust the needle to zero.
2. Atomize the high standard and adjust to 100.
3. Compare intermediate standard and adjust flame height and or other control to effect point on standard curve.
4. Repeat steps 1 and 2.
5. Atomize samples.

(d) AA can be used to determine extractable manganese, iron, zinc and copper; however micro-nutrient results may be difficult to interpret. In special cases extractable sodium may be of interest. Coloriometric procedures are used for aluminium. AA is not suitable for phosphorus, boron, sulfur and nitrogen. The following notes are provided as a guide for micro nutrient analyses.

1. Mehlich, A. 1953. Determination of P, Ca, Mg, K, Na, and $NH_4$. North Carolina Soil Test Division (Mimeo 1953).
2. Nelson, W.L., A. Mehlich, and E. Winters 1953. The development, Evaluation, and Use of Soil Tests for Phosphorus Availability. In W.H. Pierre and A.G. Norman (ed). Soil and Fertilizer Phosphorus, VOL. IV Agronomy, A Series of Monographs, Academic Press, Inc. N.Y. pp 153-188.

3. Olsen, S.R., Cole, C.J. Wathanobe, F.S., Dean, L.A., 1954, U.S. Agric, Cic. 939. 19 pp.

Watanabe, F.S. and Olsen, S.R., 1965. Test of an Ascorbic Acid Method for Determining Phosphorus in water and Sodium Bicarbonate Extract from soil. Soil Sci. Soc. of Amer. Proc. 29: 677 - 679.

Craddock and Moustache

# FERTILIZER RECOMMENDATIONS

## MARCH 1984

## FRUIT CROPS

### AVOCADO:

#### Orchard management and maintenance:

Trees should be kept healthy by fertilizer applications. Do not use a nitrate form of nitrogen fertilizer, hence do not use Nitrophoska. Preferably make use of single fertilizer; a combination of sulphate of ammonia, guano or superphosphate and potassium sulphate in a 1:1:1 mixture. An equivalent amount of Nas Urea may be preferable on red soils.

#### Fertilization:

| Time | Amount |
|---|---|
| 1st year | ½ kg of above 1:1:1 mixture in 3 split applications. Add zinc sulfate as a foliar feed at the rate of two tablespoon per three gallons of water. |
| 2nd year and onwards | 15-20 kg. of farmyard manure per year at the start of the rainy season. If manure is not available then use 2 to 5 kg of the 1:1:1 mixture per mature tree per annum in split applications. If zinc and copper deficiencies occur, they may be corrected by foliar sprays. Add 2 kg of Dolomite if soil tests indicates a low pH or low amounts of available magnesium. |

### BANANAS:

All soils on which bananas are grown should have good structure and depth, that is all soils for growing bananas should have good drainage. Dig holes 75 cm x 75 cm x 75 cm, fill half hole with well rotten debris. Add soil then 15-20 kg of farm yard manure. Sprinkle 1 kg of guano or superphosphate on top of manure and finish filling hole.

#### Fertilization:

| Time | Amount |
|---|---|
| At planting | 1 kg Nitrophoska or equivalent/ plant |
| After 2 and 4 months | Add 1 kg Ammonium Sulphate & ½ kg potassium chloride/plant. Up to 2 kg of dolomite based on soil test may be needed. |

Pen manure, if available, is often applied in the planting hole. Nitrogen gives significant and economic responses even on fertile soils. Soil tests may indicate higher or lower amounts of fertilizer materials needed.

CITRUS:

At time of transplanting dig holes 75 cm x 75 cm x 75 cm. Fill half full of semi rotten organic debris. Add some soil, then 15 to 20 kg of farm yard manure and 1 kg of guano or superphosphate.

Each year spread an additional 15 - 20 kg of manure around each tree during the rainy season.

Fertilization should be in split applications and will be most effective if added at the beginning of November and May rains. Schedule fertilizations as follows:-

Fertilization:

| Time | Amount |
|---|---|
| 1st year | 1 kg of nitrophoska or equivalent from Urea, muriate of potash, guano and dolomite/plant. |
| 2nd year | 2 kg of nitrophoska or equivalent/ plant |
| 3rd year | 3 kg of nitrophoska or equivalent/ plant |
| each ensuring year | 4 kg of nitrophoska or equivalent/ plant |

GUAVA:

Orchard management and maintenance:

Apply manure around the plants at a rate of 15-20 kg per year. Guavas respond as well to complete fertilizers as citrus, but may require more nitrogen. If zinc, copper and manganese deficiencies occur apply a foliar spray. Magnesium deficiency may be corrected by use of magnesium sulphate.

Apply nitrophoska or equivalent fertilizer with rain onset at the rate of:

Fertilization:

| Time | Amount |
|---|---|
| 1st year | 1 kg/plant |
| 2nd year | 2 kg/plant |
| each ensuring year | 3 or 4 kg/plant |

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MANGO:

In nursery grafted plants in p.v.c. bags must be watered at least twice a week, sprayed monthly and fertilized.

At time of transplanting dig holes 75 cm x 75 cm x 75 cm. Fill half full of semi-rotten organic debris. Add some soil, then 15 - 20 kg of farm yard manure and 1 kg of guano or superphosphate.

Spread 15 to 20 kg manure per year around each tree during the rainy season.

Split application of complete fertilizer will be most effective with addition made at the beginning of November and May rain. The following rates are guidelines, however soil testing may alter requirement.

| Fertilization: | Amount |
|---|---|
| 1st year | 1.00 kg |
| 2nd year | 2.00 kg |
| 3rd year | 3.00 kg |
| 4th and subsequent year | 4.00 kg |

The use of potassium nitrate (½ to 1 tablespoon/gal) spray on foliage in April and September may induce two crops/year.

PASSION FRUIT:

To the planting hole add liberal amount of manure and up to 1 kg of a complete fertilizer. Thereafter fertilizer is added as follows:-

Fertilization

| Time | Amount |
|---|---|
| 4 months after planting | ½ kg/plant of nitrophoska or equivalent |
| 9 months after planting | 1 kg/plant of nitrophoska or equivalnt |
| Thereafter | 1.5 - 2 kg of nitrophoska or equivalent/plant/year up to three years. |

Apply an additional 15 - 20 kg of manure nine months after planting on sands. Fertilizer may be the most important input to obtain high yields.

PAWPAW:

In nursery: Transplant seedling to p.v.c. plastic bag (10 x 8 cm) filled with good soil mixture and well rotted compost. Transplant to field preferably at beginning of November rain.

Apply 10 to 15 kg of farm yard manure and 1 kg nitrophoska or equivalent to planting hole.

Add well rotted compost at 5 tonnes/ha on a yearly basis. Also add fertilizer 30 - 40 cm from the base of the plant as follows:

Fertilization:

| Time | Amount (Nitrophoska/or equivalent/plant) |
|---|---|
| 6 months | 0.25 kg " |
| 6 - 12 months | 1.00 kg " |
| 1 - 2 years | 2.00 kg " |
| 2 years | 2 - 3.00 kg " |

For areas where deformed fruit has been noted use 5 - 10 kg Borax per hectare mixed with fertilizer before planting. A urea or LAN source of nitrogen is preferable to sulphate of ammonium for red soils. Sulphate of potassium is preferable to muriate of potash for first two years on all soils. A mixture of urea, guano and sulphate of potassium may be preferable to nitrophoska.

# ROOT CROPS

## CASSAVA:

On improved soils, cassava yields are within the range of 30-40 tons per hectare with the application of 600 kg of Nitrophoska and 12 tons of farm yard manure per hectare. Commonly yields of only 10 - 12 tons per hectare are being obtained.

Prepare the land with hoe or rotavator. Apply farm yard manure at the foot of the ridge at the rate of 12 tons per hectare. If the planting site was previously planted with vegetables and acceptable yields were obtained, the inputs of farm yard manure and fertilizer can be reduced considerably.

Build up soil into ridges spaced 1.6m apart. Apply nitrophoska or equivalent fertilizer in a trench at the top of the ridge at the rate of 1 kg per 30 m of ridge as a basal dressing. If micronutrient deficiencies are expected as a potential problem make beds lower than normal.

Three months after planting, weed again, apply 1 kg of nitrophoska per 30 m of ridge. This fertilizer application is critical and essential for vigorous development of foliage and will also help to control virus incidence.

## SWEET POTATO:

Yields can be in the range of 15-20 tons per hectare with the application of 600 kg of Nitrophoska or equivalent fertilizer and 15 tons of farm yard manure per hectare.

Apply farm yard manure at the foot of the ridge at the rate of 15 tons per hectare. Build up the soil into ridges spaced 1 metre apart. Apply Nitrophoska or equivalent fertilizer in a trench at top of the ridge at a rate of 1 kg per 30 metres of ridge as a basal dressing. One month after planting, apply a second does of complete fertilizer to one side of the ridge at the rate of 2 kg per 30m of ridge or amount based on soil test. Two months after planting, apply third dose of fertilizer to other side of ridge. On coraline soils amonium sulphate is preferable to urea as a source of N and guano is less effective than superphosphate.

Crop is usually harvested 4 months after planting.

Sweet potatoes responds well to organic manures. The results from artificial fertilizer trials have been conflicting. Too much nitrogen may encourage vine growth at the expense of tubers. Sweet potatoes may respond to sprays of the micronutrients boron and manganese. If crops show deficiency of iron, correct by lowering ridges to reduce oxidation and/or addition of $FeSO_4$ up to 30 kg/ha to the soil or by spraying with $FeSO_4$ or chelate at the rate of 3 kg/ha. Amount of $FeSO_4$ added to soil will depend upon severity of iron deficiency. Higher amounts up to 60 kg/ha may be added to the soil at time of bedding.

YAM:

Apply farm yard manure at the foot of the ridge at the rate of 12 tons per hectare.

Build up soil into ridges (spaced 1.6m apart). Apply nitrophoska or equivalent complete fertilizer in a trench at the top of the ridge at the rate of 1 kg per 30 metres of ridge as a basal dressing. Avoid use of urea and guano on coralline soils.

Three months after planting apply another 1 kg of nitrophoska or equivalent fertilizer per 30 metres of ridge or amounts based on soil test. Mulch with coconut leaves if available.

Yams may respond on productive soils to additional nitrogen with total nitrogen from fertilizers not exceeding 135 kg/hectare.

Application of 600 kg of Nitrophoska and 12 tons of farmyard manure per hectare are recommended for high yields up to 30 or 35 tons/ha.

## SPECIAL USE CROPS

GINGER:

Ginger can be planted on raised beds (preferably) or in trenches. Bed or trench size should be about one metre wide, should be dug deeply and worked to a fine tilth.

Liberal amounts of manure or compost should be used in the production of ginger. If a trench system is used the trench is filled with the organic materials otherwise organic material is added to the bed.

Fertilizer materials and amounts are added as follows:-

| Time | Amount |
|---|---|
| At planting | 25g (per sq.m.) of superphosphate or guano (red soil)) |
| | 4g (per sq.m) of potassium chloride |
| After 1½ months | 10g (per sq.m.) of nitrogen fertilizer |
| After 3 months | 10g (per sq.m.) of nitrogen fertilizer |
| | 4g (per sq.m.) of potassium chloride |

The crop is often mulched. A 10 cm mulch of sawdust may be applied at planting.

Soil tests may indicate higher or lower amounts of fertilizer materials to be needed.

TOBACCO:

An N.P.K. mixture in the proportion of 4:18:4 at a rate of 10 lbs per 80 sq. metres of seed bed is recommended to be applied a few days before sowing.

With flue cured tobacco avoid very fertile soils, large amounts of manuring, and excess usage of nitrogen fertilizers as these factors produce heavy leaves without desirable bright yellow or orange colors on curing. Nitrogen is usually applied at a rate of 60 kg per hectare to flue cured, up to 120 kg per hectare for dark air and fire cured tobacco and 20 kg per hectare for Turkish tobacco.

Phosphates are applied at the rate of 50 - 100 kg of $P_2O_5$ per hectare and potash at 100-150 kg $K_2O$ per hectare.

Tobacco fertilizers should contain magnesium and boron. Fertilizers and manuring ingredients should not contain large amounts of chloride or ammonium.

## VEGETABLES

### AMARANTH:

#### Fertilization Procedures:

Fertilize the bed before transplanting with farm yard manure or compost at 20 to 30 kg per 10 sq.m. of bed.

After transplanting to each 10 sq.m. of bed apply 250g of superphosphate (or 120g of superphosphate and 125g of guano) and 125g. of potassium sulphate.

Fifteen days after transplanting, apply 25g of Nitrogen as ammonium sulphate, urea or ANL per 10 sq.m. of bed.

Avoid the fertilizer falling on the leaves or young shoots. Soil tests may indicate higher or lower rates of fertilizer materials at time of bed preparation.

### BEETROOT:

On the nursery bed apply a liberal amount of farmyard manure (20 to 30 kg) and the following fertilizer materials for every 10 square metre of bed.

190g. ammonium sulphate (sand soil). Use urea for red soils.

275g. superphosphate or 150g. of superphosphate and 150g. of guano

170g. potassium sulphate

In the field, after transplanting, add liberal amount of farm yard manure (20 to 30 kg) and the following fertilizer materials per 10 square metres of bed.

720g. of superphosphate or 320g of superphosphate and 400g of guano

360g. of potassium sulphate

A soil test may indicate higher or lower rates to be needed.

Seven days after transplanting apply:-

550g. of ammonium sulphate in a band 5 cm away from the

plant for each 10 sq.m. of bed.

BOTTLE GOURD - CALEBASSE

Use liberal amount of farm yard manure(5 - 10 kg per hole) or compost in the planting hole as well as:-

75g. of super triple phosphate or 95g. of superphosphate

65g. of potassium chloride

One month later apply:-

100g. of ammonium sulphate to each planting hole.

CABBAGE:

Fertilization:-

Cabbage is very exacting and demanding in its mineral nutrition.

In the nursery apply 2 tin full (condensed milk tin) of nitrophoska or its equivalent per 10 sq.m. of bed.

At transplanting for every 10 sq.m. of bed apply:-

475g. of Superphosphate (or for red soils
275g. of Superphosphate and 200g. of guano)

360g. of Potassium sulphate

Ten days after transplanting, apply 475g. of Ammonium sulphate for each 10 sq.m. of bed.

A soil test may indicate a need for higher or lower rates of fertilizer materials to be needed.

CARROT:

Add liberal amount of farmyard manure (10-15 kg) to the planting bed as well as the following fertilizer materials for each 10 sq. m. of bed.

100g. of triple superphosphate and 90g of guano

240g. of potassium sulphate

240g. of ammonium sulphate

A soil test may indicate a need for more or less amounts of fertilizer materials.

CHINESE CABBAGE:

In the nursery, apply 2 two full tins (condensed milk tin) of Nitrophoska or equivalent per 10 sq.m. of bed.

At transplanting apply 180g. of triple superphosphate or 100g. of triple super and 80g. of guano and 360g. of potassium sulphate.

Ten days after transplanting apply 475g. of Ammonium sulphate (that is 1½ tin full).

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Soil tests may indicate higher or lower rates of fertilizer materials to be needed.

CHOUCHOUTE:

Chouchoute is responsive to fertilizer applications:-

At planting apply about 120g. of triple superphosphate or 150g. of superphosphate.

120g. of potassium chloride

Three weeks later apply in a circle around the plants in each hole 180g. of ammonium sulphate or equivalent amount of nitrogen as LAN.

COWPEA - YARDLON BEAN:

To the planting bed, apply to each 10 sq.m. of bed:-

300g. of superphosphate or 150g. of superphosphate and 150g. of guano

120g. of potassium chloride

Fifteen days later, apply for each 10 sq.m. of bed

200g. of ammonium sulphate if plants show yellow colour due to lack of nodulation.

CUCUMBER:

Apply farm yard manure generously. 15 - 20 kg per 10 square metre of bed.

For each 10 sq.m. of bed, apply 1 kg (3 tin full) of a complete fertilizer, (nitrophoska or equivalent). Do not add excess nitrogen fertilizers.

EGGPLANT:

It is a very demanding plant as far as fertilizer is concerned.

In the nursery add the following per 10 sq.m. of bed:-

190g. ammonium sulphate

275g. triple superphosphate

300g. potassium chloride

Before transplanting, on the transplanting bed, add the folowing per 10 sq.m. of bed.

770g. superphosphate or 400g. of superphosphate and 370g. of guano

300g. potassium chloride

Three weeks after transplanting, add 360g. of ammonium sulphate or equivalent amount of N as LAN per 10 sq.m. of bed

A soil test may indicate a need for more or less amounts of fertilizer materials.

FRENCH BEAN - HARICOT

To the planting bed, apply to each 10 sq.m. of bed

300g. of superphosphate or 150g. of superphosphate and 150g. of guano

120g. of potassium chloride

Fifteen days later, apply for each 10 sq.m. of bed

200g. of ammonium sulphate or equivalent amount of N as LAN.

KOHL RABI:-

Before planting, apply adequate organic matter (10-15 kg per sq.m. of bed) as well as 300g. of superphosphate and 120g. of potassium chloride for every 10 sq.m. of bed or 150g. of superphosphate and 150g. of guano

Fifteen days after planting, apply about 200g. of ammonium sulphate in a band for every 10 sq.m. of bed. A soil test may indicate higher or lower rates needed.

LETTUCE:

Avoid excessive usage of mineral fertilizers, especially those containing nitrogen.

Before transplanting, apply 250g. of superphosphate or 150g. of superphosphate and 100g. of guano and 125g. of potassium chloride for every 10 sq.m. of bed.

Ten days after transplanting, apply 300g. of ammonium sulphate (that is 1 tin full) in a band 5-10 cm away from the plant for every 10 sq.m. of bed.

OKRA - LALO:

In each planting hole, apply about 150g. (1/3 tin full) of a mixture of 2/3 superphosphate and 1/3 potassium chloride.

One month later, when the seedlings are about fifteen days, apply 50g. of ammonium sulphate (3 match box full) in each planting hole.

PUMPKIN - GIRAUMON:

Apply in each planting hole, a liberal amount of farm yard manure or compost as well as:-

70g. of triple super or 90g. of superphosphate.

40g. of potassium chloride

One month later apply to the planting hole:-

100g. of ammonium sulphate or equivalent amount of N as LAN.

SNAKE GOURD - PATOLE:

Apply adequate amount of farm yard manure (5-10kg per hole)

in each planting hole and the following:-

70g. triple superphosphate or 90g. of superphosphate

40g. potassium chloride

One month after planting apply:-

100g. ammonium sulphate or equivalent amount of N as LAN around the plants in the planting hole.

SWEET PEPPER:

In the nursery for every 10 sq.m. of bed, apply the following:-

190g. of ammonium sulphate

275g. of superphosphate or 275g. of guano

370g. of potassium sulphate

On the planting bed for every 10 sq.m. of bed, apply:-

480g. of superphosphate or 280g. of superphosphate and 200g. of guano

120g. of potassium chloride

After fifteen days, apply the following:-

120 to 180g. of ammonium sulphate for each 10 sq.m. of bed

At flowering add 120g. of ammonium sulphate for each 10 sq.m. of bed.

TOMATO:-

In the nursery apply adequate amount of farm yard manure of about 40 kg per 10 sq.m. of bed. At the same time apply about 750g. of nitrophoska (12:12:17) or equivalent per 10 sq.m. of bed.

During vegetable growth, add a match box full of nitrophoska or equivalent per plant about 10 cm away from each plant in a circle. Available source of Ca is necessary to avoid blossom end rot. Adjust soil to pH level of 5.8 or higher with dolomite limestone. Use $Ca(NO_3)_2$ or LAN as a source of Nitrogen on new land or where blossom end rot is a problem.

COCONUTS:

For transplants, to the planting hole add 15 to 20 kg. of well rotten compost (seaweeds, husks, farmyard manure, etc). If the high rates of production are desired add up to 300 grams of sulphate of ammonia and 100 grams of KCl three times a year for each tree.

Iron, manganese and zinc deficiency of young plants may be corrected by spraying compounds on the foliage. In other trees a six inch iron nail may be driven into trunk to correct iron deficiency.

APPENDIX 7: Accounting of expenditures as of June 30, 1984

Status of Funding

Seychelles: Food Crop Research
Contract Number: AFR/0001-C-00-1032-00

| | Budget | Expenditures to Date (5/31/84) | Invoices Pending | Estimated Unexpended Funds |
|---|---|---|---|---|
| Salaries and Fringe | $ 446,640 | $ 403,326.36 | $ 1,177.38 | $ 42,136.26 |
| Overhead | 77,539 | 76,060.65 | 4,402.02 | [2,923.67] |
| Travel | 180,257 | 161,596.29 | 117.00 | 18,543.71 |
| Consultants | 45,934 | 27,602.46 | - | 18,331.54 |
| Materials and Supplies | 100,570 | 115,625.23 | - | [15,055.23] |
| Allowances | 183,866 | 170,323.84 | 173.00 | 13,369.16 |
| Procurement | .00 | 10,002.88 | - | [10,002.88] |
| Participant Training | 61,329 | 22,265.50 | [1,380.00] | 40,443.50 |
| Other Direct Costs | 95,859 | 122,119.80 | 25,048.03 | [51,308.83] |
| Subtotal | $ 1,191,994 | $ 1,108,923.01 | $ 29,537.43 | $ 53,533.56 |
| G&A | 238.006 | 234,505.99 | 6,363.98 | [2,863.97] |
| TOTAL | $ 1,430,000 | $ 1,343,429.00 | $ 35,901.41 | $ 50,669.59 |

The Draft Final Voucher will be submitted after SECID's independent audit is completed at the end of our fiscal year (September 30, 1984). Final G&A rate will be set at that time.