PLANT AND VEGETABLE DISEASES REPORT

COMMERCIAL AGRICULTURAL PRODUCTION AND MARKETING PROJECT

Contract No. 645-0229-C-00-9019

Prepared in association with :

United States Agency for International Development

and

The Ministry of Agriculture and Co-operatives
Mbabane, Swaziland

Prepared by :

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March, 1994

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INTRODUCTION

A. Objectives

Dr. Alan MacNab served as a short-term plant pathologist / vegetable disease consultant from April 16 to May 8, 1993. This consultant was fielded to work with the project production team in identifying and treating diseases related to vegetable crops. His scope of work (Annex F), included Commercial Agriculture Production and Marketing (CAPM) project's winter production crops, revising the current calendar-based chemical control program, reviewing current disease controls for vegetables listed in the Farmers Handbook, examining the potential for using integrated pest management procedures and, training farmers and CAPM field staff.

The focus of this effort was field-orientated and directed towards activities that would directly benefit the farmers. This report is a brief summary of the consultant's findings and recommendations accompanied by supporting documentation.

B. Review Disease Control Programs Developed for Crops in CAPM

Disease control programs previously developed for use in the CAPM program were reviewed and revised. Revised programs for Beans, Corn, Pepper, Potato, and Tomato are included in Appendix A.

C. Develop Disease Control Programs for New Crops in CAPM Program

Disease management programs were developed for Onions, Vine Squash, and Crucufers (cabbage and broccoli), crops which have not been extensively grown in the CAPM project. Various management methods were included as appropriate. These are included in Appendix B.

D. Farmer Field Meeting Materials

Educational materials were prepared by use by CAPM and MOAC personnel who work with vegetable producers on disease

control programs. These materials are discussed below under "Integrated Pest Management" as Item F.

E. In-Service Training in Vegetable Disease Identification and Control

Educational training for CAPM Field Assistants and Government Extension Workers was provided on March 25 and 28. The objectives for the workshop were:

1. To increase participants knowledge about vegetable diseases.
2. Provide each written back-up material on vegetable disease identification and control.
3. Help provide both Extension workers in the Ministry of Agriculture and CAPM Field Advisors with an opportunity to increase their confidence in working with vegetable diseases.

Materials presented in a classroom setting included some principles of plant pathology, and disease identification and control material on the following crops : Cabbage and broccoli, onions, beans, cucurbits, corn, tomatoes and peppers. Problems on tomatoes, peppers and beans were observed in several field situations where participants shared their observations, considered clues helpful in diagnosis, and considered control measures. Actual outline of the In-service Training is presented in Appendix C.

Interest in the training was demonstrated by attendance and participants. A total of 23 people attended the In-Service Training event. This was 12 more than we expected. Attendees included the 3 CAPM Field Assistants, 18 MOAC (Ministry of Agriculture and Cooperatives) representatives, and 2 PSI seed company representatives. At the end of the training a certificate was presented to each attendee. A sample is present as Appendix C.

F. In-Service Training in Lab Diagnosis of Vegetable Disease

Educational training for appropriate CAPM (Doyle Grenoble and Jabulani Sifundza) and available Malkerns Research Station personnel (Doug Gama, Station Horticulturist, and Leonard

, Station Entomologist) was provided in the Entomology Research Lab on March 22. Materials used during the training event are presented in Appendix D.

The objectives for the training were:

1. To increase participants knowledge about the potential for use of lab procedures.
2. Familiarize participants with tests to help verify field diagnosis of vegetable diseases.

During this In-Service Training we considered the importance of accurate diagnosis, reviewed some lab procedures useful in diagnosis (making dry and wet mounts, and use of a compound microscope), considered the difficulty of lab isolation and culturing in a field lab, provided introductory reference material for use in identification on preparation of 13 genera of disease-causing fungi, and provided information on preparation of plant samples for shipment to a lab for serological identification of vegetable viruses.

All attendee indicated that the training was worthwhile and requested additional follow-up training for themselves and others whenever it can be arranged.

G. Integrated Pest Management

A leaflet titled "What is Integrated Pest Management ?" was prepared for use at educational meetings held for vegetable growers. This was prepared to stress the importance of using all possible methods to manage problems caused by disease-causing organisms (fungi, bacteria, nematodes, and viruses), insects, mites, and weeds. A copy is presented in Appendix E.

Appropriate pest management information was integrated into "Insect and Disease Management Sheets" prepared for specific crops. These are referred to above and are presented in Appendicies A and B.

Additional resource materials on identification and management of specific vegetable diseases were prepared for use by CAPM and MOAC personnel during their work with farmers. These are included in Appendix E.

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H. Opportunities for Cooperative Projects With South African Agriculturists.

South Africa has a number of resources that could be helpful to Swaziland. Similarly, CAPM has resources and contacts that could be helpful to South Africa. Doyle Grenoble anticipated this opportunity and arranged for a visit to the Roodeplaat Vegetable and Ornamental Plant Institute as a way to explore potential for such cooperation. On March 17, Doyle Grenoble, Jabulani Sifundza, and I visited the Institute, met with the key personnel at the Institute, participated in a "Post Harvest Workshop" and visited a large hydroponic vegetable producer. We made may contacts that could be very useful to Swaziland in the future. Some opportunities provided by this visit are outlined in Appendix F.

I. Specific Tasks Undertaken

1. Review Disease Control Programs Developed for Crops in CAPM :

Disease control programs previously developed for use in the CAPM program were reviewed and revised. Revised programs for Beans, Corn, Potato, and Tomato are included in Appendix A.

2. Develop Disease Control Programs for New Crops in CAPM Program :

Disease management programs were developed for Onion, Vine Squash, and Crucufers (cabbage and broccoli), crops which have not been extensively grown in the CAPM project. Various management methods were included as appropriate. These are included in Appendix B.

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Objectives : To increase participants knowledge about vegetable diseases, provide each with written back-up material on vegetable disease identification and control, and help provide both Extension workers in the Ministry of Agriculture, and CAPM Field Advisors with an opportunity to increase their confidence in working with vegetable diseases.

Contents : Material presented in a classroom setting included some principles of plant pathology, and disease identification and control material on the following crops: Cabbages and broccoli, onions, beans, cucurbits, corn, tomatoes and peppers. Problems on tomatoes, pepper and beans were observed in several field situations where participants shared their observations, considered clues helpful in diagnosis, and considered control measures. Actual outline of the In-Service Training is presented in Appendix C.

Results : Interest in the training was demonstrated by attendance and participation. A total of 23 people attended the In-Service Training event. This was 12 more than we expected. Attendee included the 3 CAPM Field Assistants, 18 MOAC (Ministry of Agriculture and Cooperatives) representatives, and 2 PSI seed company representatives. At the end of the Training, a certificate was presented to each attendee. A sample is presented in Appendix C.

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Objectives : To increase participants knowledge about the potential for use of lab procedures and tests to help verify diagnosis of vegetable diseases.

Content : During this In-Service Training, we considered the importance of accurate diagnosis, reviewed some lab procedures useful in diagnosis (making dry and wet mounts, and use of a compound microscope), considered the difficulty of lab isolation and culturing in a field lab, provided introductory reference material for use in identification of 13 genera of disease-causing fungi, and provided information on preparation of

plant samples for shipment to a lab for serological identification of vegetable viruses.

Results : All attendees indicated that the training was worthwhile and requested additional follow-up training for themselves and others whenever it can be arranged.

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Appropriate pest management information was integrated into "Insect and Disease Management Sheets" prepared for specific crops. These are referred to above and are presented in Appendicies A and B.

Additional resource materials on identification and management of specific vegetable diseases were prepared for use by CAPM and MOAC personnel during their work with farmers. These are included in Appendix E.

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Appendix A

Revised Disease and Insect Control Programs

Green Beans
Sweet Corn
Pepper (Summer)
Pepper (Winter)
Potato (Summer)
Tomato (Winter)

Bean Disease Management Program

Diseases: Leaf rust and pod anthracnose are reported as the most important diseases. During wet seasons, white mold pod rot could become important at harvest, during transit and in storage. Rust is favored by high humidity and moderate temperatures of 18-28 °C. Anthracnose is favored during cool wet seasons or when overhead irrigation is used. White mold development requires wet soil conditions shortly before blossoming, and is promoted by warm moist conditions during pod formation.

Disease Controls: For all diseases, provide at least 2 years between bean crops. For rust, use tolerant varieties if possible (eg. Roma and Spurt). For anthracnose, start with disease-free seed (ie. seed grown in areas without anthracnose). Where a rust problem is anticipated, make weekly applications of chlorothalonil (Bravo) starting no later than onset of first symptoms. Where a white mold problem is anticipated, make one application of benomyl (Benlate) to provide good coverage of buds when about 70% of plants have one open blossom (be careful not to make this application too late); if necessary, a second application may be helpful about 5 days later.

Disease Spray Program*:

Product	No. tbs/ 15 liters	Remarks
Bravo 50 sc (7)	5.0	Rust
Benlate 50 wp (14)	1.5	White mold

( ) = Minimum number of days required between final pesticide application and harvest.

* For rust, make weekly applications of Bravo starting no later than onset of first symptoms.
* For white mold, if disease is anticipated, make one application of Benlate to provide good coverage of blossoms and buds when about 70% of plants have one open blossom. If necessary, a second application can be made about 5 days later.

Number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover one hectare.

One level full matchbox is equal to 1 tablespoon (15 ml).

This list is intended as a guide only. In some cases, other chemicals may be effective. The same chemical often is sold under several different trade names. The use of a particular trade name is not intended to be discriminatory nor is it an endorsement of the product.

Sweet Corn Disease Management Program

Diseases: Streak virus, leaf rust, fungus leaf blights. Both rust and leaf blight (NCLB) are favored by cool moist conditions.

Disease Controls: For the fungus leaf diseases, rotate with crops other than corn and as possible, plant varieties with tolerance. For streak virus, control the leafhopper vector by using Curater in the furrow at planting, and where necessary, avoid late summer plantings. For all diseases, when possible, avoid making successive plantings of corn in adjacent strips. If necessary for late summer plantings, fungicides may slow development of fungal leaf defoliation diseases. To minimize future disease development, when possible, plow under debris from diseased plants.

Disease Spray Program*:

Product	No. tbs/ 5 liters	Remarks
Dithane M45 (7)	2.5	Rust & Leaf Blights
or		
Bravo 50 sc (14)	1.	

( ) = Minimum number of days required between final pesticide application and harvest.

* Watch plants for presence of rust and leaf blights. In early plantings, these leaf diseases may not appear until relatively late during the normal plant development cycle. However, in late plantings, especially when conditions are moist, these leaf diseases may appear earlier during the normal plant development cycle. If rust or blights appear prior to appearance of tassels, weekly applications of Dithane M45 or Bravo may be warranted and should slow development of defoliation.

Number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover one hectare.

One level full matchbox is equal to 1 tablespoon (15 ml).

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Summer Pepper Insect and Disease Management Program

Diseases: Some of the most common diseases seen or reported in Swaziland are Bacterial spot, bacterial wilt, powdery mildew, Cercospora leaf spot, fungus fruit rots, and viruses. Although these diseases are possible, most of the diseases seldom develop when appropriate disease management practices are followed. Bacterial spot is favored by warm wet conditions. Bacterial wilt is favored by warm wet conditions, especially when roots are injured by cultivation or nematodes. Powdery mildew is favored by moderate temperatures and relatively low humidity.

Disease Controls: Rotate to provide as many years as possible between pepper, eggplant, potato, and/or tomato crops (2 years for spot, 4 or more years for bacterial wilt). Rotation could be of limited value for bacterial wilt because many solanaceous crops (cultivated and weeds), peanuts, and bananas can be affected. Start with pathogen-free seed and transplants. Try to avoid root injury during cultivation. Use of trickle irrigation should minimize plant-to-plant spread of the bacterial wilt pathogen, whereas spread is promoted by furrow irrigation. When bacterial spot is present, do not work in plantings when leaf surfaces are wet. Sprays are useful for powdery mildew control, and sometimes slow spread of bacterial spot.

Insect and Disease Spray Program:

Week (from planting)	Product Remarks	No. tbs/ 15 liters
*	Copper oxychloride (3) Bacterial spot	9.0
	+ Dithane M45 (3)	15.0
3	Benlate 50 wp (3) Powdery mildew	1.5
5	Benlate 50 wp (3) Powdery mildew	1.5
	Malathion 25 wp (3) Aphids	6.0
7	Benlate 50 wp (3) Powdery mildew	1.5
	Kelthane 18.5 wp (7) Mites	3.0
9	Benlate 50 wp (3) Powdery mildew	1.5
	Malathion 25 wp (3) Aphids	6.0
11	Benlate 50 wp (3) Powdery mildew	1.5
	Kelthane 18.5 wp (7) Mites	3.0

Week (from planting)	Product Remarks	No. tbs/ 15 liters
13	Benlate 50 wp (3) Powdery mildew	1.5
	Malathion 25 wp (3) Aphids	6.0
15	Benlate 50 wp (3) Powdery mildew	1.5
	Kelthane 18.5 wp (7) Mites	3.0

( ) = Minimum number of days required between final pesticide application and harvest.

* = Watch plants for bacterial spot symptoms. Usually, it does not appear. If bacterial spot does appear, weekly applications of copper oxychloride + Dithane M45 will slow spread.

If aphids, mites, or powdery mildew appear in the area, switch to weekly sprays.

Number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover one hectare.

One level full matchbox is equal to 1 tablespoon (15 ml).

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March 28, 1994.

Winter Pepper Insect and Disease Management Program

Diseases: Some of the most common diseases seen or reported in Swaziland are Bacterial spot, bacterial wilt, powdery mildew, Cercospora leaf spot, fungus fruit rots, and viruses. Although these diseases are possible, most of the diseases seldom develop when appropriate disease management practices are followed. Bacterial spot is favored by warm wet conditions. Bacterial wilt is favored by warm wet conditions, especially when roots are injured by cultivation or nematodes. Powdery mildew is favored by moderate temperatures and relatively low humidity.

Disease Controls: Rotate to provide as many years as possible between pepper, eggplant, potato, and/or tomato crops (2 years for spot, 4 or more years for bacterial wilt). Rotation could be of limited value for bacterial wilt because many solanaceous crops (cultivated and weeds), peanuts, and bananas can be affected. Start with pathogen-free seed and transplants. Try to avoid root injury during cultivation. Use of trickle irrigation should minimize plant-to-plant spread of the bacterial wilt pathogen, whereas spread is promoted by furrow irrigation. When bacterial spot is present, do not work in plantings when leaf surfaces are wet. Sprays are useful for powdery mildew control, and sometimes slow spread of bacterial spot.

Insect and Disease Spray Program:

Week (from planting)	Product	No. tbs/ 15 liters	Remarks
*	Copper oxychloride (3) + Dithane M45 (3)	9 15	Bacterial spot
* *	Benlate 50 wp (3) or Copper oxychloride (3) or Sulphur wp (3)	1.5 9 10	Powdery mildew
5	Malathion 25 wp (3)	6	Aphids
7	Kelthane 18.5 wp (7)	3	Mites
9	Malathion 25 wp (3)	6	Aphids
11	Kelthane 18.5 wp (7)	3	Mites
13	Malathion 25 wp (3)	6	Aphids
15	Kelthane 18.5 wp (7)	3	Mites

( ) = Minimum number of days required between final pesticide application and harvest.

* = Watch plants for bacterial spot symptoms. Usually, it does not appear. If bacterial spot does appear, weekly applications of copper oxychloride + Dithane M45 will slow spread.

** = Watch plants for powdery mildew symptoms. Where mildew is anticipated, start weekly sprays a few weeks before it usually appears. Copper oxychloride also will mimimize bacterial spot if it is present but could stunt plants when temperatures are high. Sulphur may help minimize mite problems but may burn plants some when temperatures are high. Benlate is safe at all temperatures.

Number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover one hectare.

One level full matchbox is equal to 1 tablespoon (15 ml).

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March 28, 1994.

Summer Potato Disease and Insect Management Program

Diseases: Bacterial wilt and fungus leaf blights (early blight and late blight) likely are the most prevalent diseases. Bacterial wilt is favored by warm wet conditions, especially when roots are injured by cultivation or nematodes. Both early and late blights are favored by wet conditions. Early blight can develop over a wide range of temperatures. Late blight will be most severe during relatively cool conditions.

Disease Controls: Rotate to provide as many years as possible between solanaceous crops (2 years early blight, 4 or more years for bacterial wilt). Rotation could be of limited value for bacterial wilt because many solanaceous crops (cultivated and weeds), peanuts, and bananas can be affected. Use resistant varieties when possible. Start with pathogen-free seedstock. When leaf spots are present, do not work in plantings when leaf surfaces are wet. Maintain adequate plant vigor. Try to avoid root injury during cultivation. Use of trickle irrigation may minimize plant-to-plant spread of the bacterial wilt pathogen, whereas spread can be promoted by furrow irrigation. Where leaf blights are anticipated, start protective fungicide applications a couple of weeks before first symptoms usually appear, and continue throughout the season.

Insect and Disease Spray Program:

Week (from planting)	Product	No. tbs/ 15 liters	Remarks
2	Copper oxychloride (3)	8	Early & Late Blight
	+ Dithane M45 (3)	16	
3	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
4	Copper oxychloride (3)	8	Early & Late Blight
	+ Dithane M45 (3)	16	
	Patron = Cyromazine (3)	1	Leaf Miner
	Talstar (5)	1	Red Spider
5	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
6	Copper oxychloride (3)	8	Early & Late Blight
	+ Dithane M45 (3)	16	
	Curacron (4)	3	Aphids, Red Spider, Leaf miner
7	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	

Week (from planting)	Product	No. tbs/ 15 liters	Remarks
8	Copper oxychloride (3)	8	Early & Late Blight
	+ Dithane M45 (3)	16	
	Patron = Cyromazine (3)	1	Leaf Miner
	Talstar (5)	1	Red Spider
9	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
10	Copper oxychloride (3)	8	Early & Late Blight
	+ Dithane M45 (3)	16	
	Curacron (4)	3	Aphids, Red Spider, Leaf miner
11	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
12	Copper oxychloride (3)	8	Early & Late Blight
	+ Dithane M45 (3)	16	
	Curacron (4)	3	Aphids, Red Spider, Leaf miner
13	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
14	Copper oxychloride (3)	8	Early & Late Blight
	+ Dithane M45 (3)	16	
	Curacron (4)	3	Aphids, Red Spider, Leaf miner
15	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	

( ) = Minimum number of days required between final pesticide application and harvest.

Number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover one hectare. One level full matchbox is equal to 1 tablespoon (15 ml).

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March 28, 1994.

Winter Tomato Disease and Insect Management Program

Diseases: Bacterial wilt and fungus leaf blights (early blight and late blight) are the most prevalent diseases. In addition, bacterial fruit spots, powdery mildew and ripe fruit rots can develop. Bacterial wilt is favored by warm wet conditions, especially when roots are injured by cultivation or nematodes. Both early and late blights are favored by wet conditions. Early blight can develop over a wide range of temperatures. Late blight will be most severe during relatively cool conditions.

Disease Controls: Rotate to provide as many years as possible between solanaceous crops (1 year for speck, 2 years for spot and early blight, 3 years for canker, 4 or more years for bacterial wilt). Rotation could be of limited value for bacterial wilt because many solanaceous crops (cultivated and weeds), peanuts, and bananas can be affected. Use resistant varieties when possible. Maximillion and Rotam 4 have resistance to bacterial wilt but Rotam 4 has other characteristics which are poor; other varieties with tolerance include Rodade, Zeal (determinate), and Zest (indeterminate). Floradade and Nema varieties are susceptible. Start with pathogen-free seed and transplants. When fruit and leaf spots are present, do not work in plantings when leaf surfaces are wet. Maintain adequate plant vigor. Try to avoid root injury during cultivation. Use of trickle irrigation should minimize plant-to-plant spread of the bacterial wilt pathogen, whereas spread can be promoted by furrow irrigation. Where leaf blights and fruit rots are anticipated, start protective fungicide applications no later than first fruit set, and continue throughout the season. Try to avoid submerging fruit in water after harvest.

Insect and Disease Spray Program:

Week (from planting)	Product	No. tbs/ 15 liters	Remarks
2	Copper oxychloride (3)	8	Bacterial Spot, Early
	+ Dithane M45 (3)	16	Blight & Late Blight
3	Bravo 50 sc	4	Early & Late Blight
	or Dithane M45 (3)	16	
4	Copper oxychloride (3)	8	Bacterial Spot, Early
	+ Dithane M45 (3)	16	Blight & Late Blight
	Patron = Cyromazine (3)	1	Leaf Miner
	Talstar (5)	1	Red Spider
5	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	

Week (from planting)	Product	No. tbs/ 15 liters	Remarks
6	Copper oxychloride (3)	8	Bacterial Spot, Early
	+ Dithane M45 (3)	16	Blight & Late Blight
	Curacron (4)	3	Aphids, Red Spider, Leaf miner
7	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
8	Copper oxychloride (3)	8	Bacterial Spot, Early
	+ Dithane M45 (3)	16	Blight & Late Blight
	Patron = Cyromazine (3)	1	Leaf Miner
	Talstar (5)	1	Red Spider
9	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
10	Copper oxychloride (3)	8	Bacterial Spot, Early
	+ Dithane M45 (3)	16	Blight & Late Blight
	Curacron (4)	3	Aphids, Red Spider, Leaf miner
11	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	
12	Copper oxychloride (3)	8	Bacterial Spot, Early
	+ Dithane M45 (3)	16	Blight & Late Blight
	Curacron (4)	3	Aphids, Red Spider, Leaf miner
13	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	

Week (from planting)	Product	No. tbs/ 15 liters	Remarks
14	Copper oxychloride (3)	8	Bacterial Spot, Early
	+ Dithane M45 (3)	16	Blight & Late Blight
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15	Bravo 50 sc (3)	4	Early & Late Blight
	or Dithane M45 (3)	16	

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March 28, 1994.

Appendix B

New Disease and Insect Control Programs

Cabbage, Cauliflower, and Broccoli
Onion
Vine Squash

CABBAGE, CAULIFLOWER, & BROCCOLI: INSECT AND DISEASE CONTROL PROGRAM

Diseases: Black Rot (BR), Downy Mildew (DM), and Alternaria Leaf Spot (LS):

Environment: BR develops well at moderate temperatures near 24 °C. DM is favored by cool moist conditions. Leaf spot is favored by 9 hours of leaf wetness per day.

Controls: Rotate to allow at least 2 years between cole crops. Use well-drained soils away from windbreaks, especially for DM. Avoid planting next to older plantings where disease is present. **Broccoli** varieties with some resistance to DM include Dandy Early, Green Valiant, Hi Caliber, Shogun and Green Belt, and with resistance to BR are Shogun, and Green Top. **Cabbage** varieties with resistance to DM include Grandslam, and to BR include Showboat, AA&C#5, Hercules, and Conquistador. Start with disease-free seed and transplants. Where disease is anticipated, apply fungicides for DM during cool moist periods, and for leaf spot during periods when leaves are wet daily for 9 hour periods. When harvest is complete, remove, destroy or bury crop residue if possible.

Fungicides: Dithane M45 is effective and economical for DM and leaf spot. Bravo also is possible. For DM, when day temperatures are less than 25 °C, fixed copper materials such as coper oxychloride and copper hydroxide are effective and economical but may be phytotoxic at high temperatures. For DM, if necessary, Ridomil/Bravo and Ridomil MZ are excellent; if the Ridomil materials are more expensive, they may be warranted only during extreme conditions.

CABBAGE, CAULIFLOWER, & BROCCOLI: INSECT AND DISEASE SPRAY PROGRAM

Week (from planting)	Product	No. tablespoons per 15 l	20 l	Remarks
2	Curacron (7) or	3.0	4.5	Diamond back moth, A.bollworm, aphids, cabbage moth
	Ripcord* (4)	1.0	1.3	
3	Curacron (7) or	3.0	4.5	Diamond back moth, A.bollworm, aphids, cabbage moth
	Ripcord* (4)	1.0	1.3	
	+ Dithane M45	12	16	Downy Mildew**
4	Curacron (7) or	3.0	4.5	Diamond back moth, A.bollworm, aphids, cabbage moth
	Ripcord* (4)	1.0	1.3	
	+ Dithane M45	12	16	Downy Mildew**

5	Curacron (7) or	3.0	4.5	Diamond back moth, A.bollworm,
	Ripcord* (4)	1.0	1.3	aphids, cabbage moth
	+ Dithane M45	12	16	Downy Mildew**
6	Curacron (7) or	3.0	4.5	Diamond back moth, A.bollworm,
	Ripcord* (4)	1.0	1.3	aphids, cabbage moth
	+ Dithane M45	12	16	Downy Mildew**
8	Curacron (7) or	3.0	4.5	Diamond back moth, A.bollworm,
	Ripcord* (4)	1.0	1.3	aphids, cabbage moth
10	Curacron (7) or	3.0	4.5	Diamond back moth, A.bollworm,
	Ripcord* (4)	1.0	1.3	aphids, cabbage moth

Important! A wetting agent such as CITOWET or AGRAL 90 (4 ml/sprayer) should be added to all spray applications.

* Ripcord will not control aphids.
** If symptoms of downy mildew or Alternaris leaf spot are not present, it is not necessary to apply Dithane M45.

The number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover 1 hectare.

This list is intended as a guide only. If you or the Field Assistant detect an unforseen problem, other treatments may be considered. In some cases, other pesticides may be effective. The same chemical often is sold under several different trade names. The use of a trade name is not intended to be discriminatory nor is it an endorsement of the product. 25/3/94 CAPM

ONION: INSECT & DISEASE CONTROL PROGRAM

Leaf Diseases: Downy Mildew, Purple Blotch, and Botrytis Blast:

Environment: Downy mildew is favored by cool moist conditions; spores can not survive long when dry. Blotch and blast are favored by moisture, high RH and moderate temperatures.

Controls: Rotate to allow at least 3 years between bulb crops. Eliminate cull piles where pathogens could survive between crops. Use well-drained soils away from windbreaks, especially for DM. Avoid making new plantings next to older plantings where disease is present. Start with disease-free seed or sets. When harvest is complete, remove, destroy or bury crop residue. Where disease is anticipated, apply fungicides for downy mildew during cool moist periods, and for blotch and blast during periods when leaves are wet for long periods, humidity is high, and temperatures are moderate.

Fungicides: Dithane M45 is effective and economical for downy mildew, blotch and blast, but should not be used on green bunching onions. Bravo is possible for all onions; on green bunching onions, applications must be stopped 14 days before harvest. For downy mildew, if necessary, Ridomil/Bravo and Ridomil MZ are excellent. If the Ridomil materials are more expensive, they may be warranted only during extreme conditions. For blast, weekly fungicide applications should be started by the time an average of 1 lesion is detected on 10 leaves.

Important Notes! A wetting agent such as CITOWET or AGRAL 90 (4 ml/sprayer) should be added to all spray applications. Use adequate spray volume to allow complete coverage.

Dithane M45 should not be used on green bunching onions. Bravo can be used on green bunching onions until 14 days before harvest.

Chemicals listed for the same week can be mixed together in the spray tank. Powders should always be added to the water first and liquid materials added to the tank just before the last of the water is added.

Number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover 1 hectare. One level full match box is equal to 1 tablespoon.

The above list is intended as a guide only. In some cases, other chemicals may be effective. The same chemical often is sold under several different trade names. The use of a particular trade name is not intended to be discriminatory nor is an endorsement of the product implied.

25/3/94 CAPM

ONION: INSECT AND DISEASE SPRAY PROGRAM

Week (from planting)	Product	Tbs./ 5 liters	Remarks
4	Dithane M45	2	Downy mildew, Blotch, Blast
	Malathion 25wp	2	Thrips
5	Dithane M45	2	Downy mildew, Blotch, Blast
	Malathion 25wp	2	Thrips
6	Dithane M45	2	Downy mildew, Blotch, Blast
	Malathion 25wp	2	Thrips
7	Dithane M45	2	Downy mildew, Blotch, Blast
	Malathion 25wp	2	Thrips
8	Dithane M45	2	Downy mildew, Blotch, Blast
	Malathion 25wp	2	Thrips
10	Dithane M45	2	Downy mildew, Blotch, Blast
	Malathion 25wp	2	Thrips

Additional sprays as needed, when the pests or diseases are evident, consisting of the following:

	Dithane M45	2	Downy mildew, Blotch, Blast
	Malathion 25wp	2	Thrips

VINE SQUASH: INSECT AND DISEASE CONTROL PROGRAM

Leaf Diseases: Powdery Mildew (PM), Downy Mildew (DM):

Environment: PM is favored by warm days and humid nights.

Controls: Avoid making new plantings near older plantings where disease is present. Where disease is anticipated, apply fungicides for PM starting as soon as any appears nearby.

Fungicides: Bravo provides fair control of PM and may be helpful if applied for other diseases such as DM. Benlate and Bayleton are most effective for PM control. When day temp. are less than 25 °C (85 °F), fixed copper materials such as copper oxychloride and copper hydroxide are effective and economical but are phytotoxic at high temp.; therefore, they should never be used before plants are nearly full size, and should be tried only with caution on older plants. For DM, if necessary, Ridomil/Bravo and Ridomil MZ are excellent; if the Ridomil materials are very expensive, they may be warranted only during extreme conditions.

VINE SQUASH: INSECT AND DISEASE SPRAY PROGRAM

Week (from emergence)	Product	Tbls./ 5 liters	Remarks
2	Benlate 50 wp (0)*	0.5	Powdery mildew
3	Bravo 50 sc (3)	2	Downy & Powdery mildew, Anthracnose
4	Benlate 50 wp (0)	0.5	Powdery mildew
5	Bravo 50 sc (3)	2	Downy & Powdery mildew, Anthracnose
6	Benlate 50 wp (0) Lebaycide ec (10)	0.5 0.25	Powdery mildew Pumpkin fly, aphids
7	Bravo 50 sc (3)	2	Downy & Powdery mildew, Anthracnose
8	Benlate 50 wp (0) Lebaycide ec (10)	0.5 0.25	Powdery mildew Pumpkin fly
9	Bravo 50 sc (3)	2	Downy & Powdery mildew, Anthracnose
10	Benlate 50 wp (0) Lebaycide ec (10)	0.5 0.25	Powdery mildew Pumpkin fly
11	Bravo 50 sc (3)	2	Downy & Powdery mildew, Anthracnose
12	Benlate 50 wp (0) Lebaycide ec (10)	0.5 0.25	Powdery mildew Pumpkin fly
13	Bravo 50 sc (3)	2	Downy & Powdery mildew, Anthracnose
14	Benlate 50 wp (0) Lebaycide ec (10)	0.5 0.25	Powdery mildew Pumpkin fly

* Number in parentheses is number of days necessary between application and harvest.

The number of tablespoons of product to be used are calculated on the basis of 300 liters of spray being required to cover 1 hectare.

If spider mites appear, Kelthane 42.5 ec (2) at 0.5 tbs/5 liters can be used.

For PM control, it may be possible to substitute Benlate for alternate Bayleton sprays. If a severe problem with DM is anticipated, Ridomil MZ can be substituted for Bravo.

This list is intended as a guide only. If you or the Field Assistant detect an unforseen problem, other treatments may be considered. In some cases, other pesticides may be effective. The same chemical often is sold under several different trade names. Use of a trade name is not intended to be discriminatory nor is it an endorsement of the product. 25/3/94 CAPM

Appendix C

In-Service Training in Vegetable Disease Identifcation and Control

In-Service Training in Vegetable Disease Identification and Control: Educational training for CAPM Field Assistants and Government Extension Workers was planned for March 25 and 28. On March 14, Doyle and I met with Ms. Tandy Lupupa, National Subject Matter Specialist in Horticulture, outlined plans for the educational event, and invited her to have her eight Extension Workers attend. She indicated that she would like them to participate.

Objectives: To increase participants knowledge about vegetable diseases, provide each with written back-up material on vegetable disease identification and control, and help provide both Extension workers in the Ministry of Agriculture, and CAPM Field Advisors with an opportunity to increase their confidence in working with vegetable diseases.

Outline of the training was as follows:

March 25, 1994:

10.00-11.00 am	Some principles of plant pathology
11.00-13.00 pm	Disease Identification and Control Cabbage and Broccoli diseases Onion diseases Bean diseases Cucurbit diseases Corn diseases
13.00-14.00 pm	Tomato problem diagnosis at Malkern's Research Station
14.00-15.00 pm	Disease Identification and Control Tomato diseases Pepper diseases

March 28, 1994:

08.00 am	Leave Manzini for Vivulane	
10.00 - 10.15 am	Welcome remarks	P. Dlamini, VIF
	Farm 1: Peppers	
10.30 - 10.40 am	Introduction	C. Dlamini
10.40 - 11.15 am	Discussions	A. MacNab & Group
	Farm 2: Tomatoes	
11.30 - 11.40 am	Introduction	C. Dlamini
11.40 - 12.15 pm	Discussions	A. MacNab & Group
	Farm 2: Beans	
12.30 - 12.40 pm	Introduction	C. Dlamini
12.40 - 13.15 pm	Discussions	A. MacNab & Group

Lunch

14.15 - 14.45 pm	Closing and Awarding of Certificates	C. Dlamini & A. MacNab

Specific crops & diseases planned for inclusion in the In-Service Training are listed on a following page.

Results: Interest in the training was demonstrated by attendance and participation. A total of 23 people attended the In-Service Training event. This was 12 more than we expected. Attendees included 3 CAPM Field Assistants, 18 MOAC representatives, and 2 PSI seed company representatives. At the end of the Training, a certificate was presented to each attendee. A sample is presented on a following page.

Crops & Diseases Considered During In-Service Training

Crop	Disease Name	Causal Organism
Beans	Rust	Uromyces phaseoli
Cole crops	Leaf spot	Alternaria brassicae
	Downy mildew	Peronospora parasitica
Cucurbits	Powdery mildew	a. Erysiphe cichoracearum.
		b. Sphaerotheca fuliginea
	Viruses	CMV, WMV, etc.
Onions	Blotch	Alternaria porri
	Downy mildew	Peronospora destructor
	Leaf Blight	a. Botrytis squamosum
		b. Botrytis cinerea
Peppers	Anthracnose spot	a. Colletotrichum capsici
		b. Colletotrichum piperatum
	Bacterial soft rot	Erwinia carotovora
	Phytophthora blight	Phytophthora capsici
	Alternaria leaf spot	a. Alternaria tenuis
		b. Alternaria alternata
		c. Alternaria solani?
	Cercospora leaf spot	Cercospora capsici
	Viruses	TMV, CMV, Etch, TSWV, etc.
Sweet Corn	Common rust	Puccinia sorghi
	(Southern rust)	Puccinia polysora
	(Tropical rust)	Puccinia zeae
	Leaf blight (NCLB)	a. Helminthosporium turcicum
		b. = Exserohilum turcicum
	Streak virus	Virus (via leafhopper)
Tomatoes	Bacterial wilt	Pseudomonas solanacearum
	Bacterial speck	Pseudomonas syringae tomato
	Bacterial spot	Xanthomonas vesicatoria
	Bacterial soft rot	Erwinia carotovora
	Early blight	Alternaria solani
	Late blight	Phytophthora infestans
	Soil rot	Rhizoctonia solani
	Water mold root rot	a. Phytophthora parasitica
		b. Phytophthora capsici
		c. Phytophthora
	Viruses (Mosaic, stunting, shoestring leaf distortions)	TMV, CMV, others.

Worksheet for participants:

Tomato

Symptoms: _____

_____

Diagnosis: _____

Which of the following favor development of this problem?

__ Root pruning during hoeing.

__ Furrow irrigation.

__ Lack of rotation

__ Windy conditions.

__ Cool nights.

__ High aphid populations.

Pepper

Symptoms: _____

_____

Possible Causes: (1) _____ (2) _____

Snap Beans

Symptoms: _____

_____

Diagnosis: _____

Which of the following could favor development of symptoms?

__ Root pruning during hoeing.

__ Furrow irrigation.

__ Lack of rotation

__ Windy conditions.

__ Cool nights.

__ High aphid populations.

The Swaziland Commercial Agricultural Production and Marketing Project

certifies that

Ndabazezwe Dlamini

attended and participated in the

Vegetable Disease In-Service Training

provided by CAPM, in Swaziland,
on March 25 and 28, 1994

Alan A. MacNab
Veg. Disease Specialist

Doyle W. Grenoble
Chief of Party

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Appendix D

Training on Procedures to Check Field Diagnosis of Diseases

Training on Procedures to Check Field Diagnoses of Diseases

Procedures to check field diagnoses of diseases were reviewed for selected personnel who had appropriate background experience. Procedures were considered for fungal, bacterial, and viral diseases.

For **fungal diseases**, methods were reviewed for making dry mounts and wet mounts using diseased material directly from the field. and using material prepared and incubated in a moist chamber; these are included on a following page. Illustrations of selected fungal structures were prepared and compiled for easy reference by diagnosticians; these are included on a following page.

For **bacterial diseases**, a test was reviewed to test tomatoes, peppers, and potatoes for presence of bacterial wilt caused by Pseudomonas solanacearum. This same test could be used to test cucurbits for presence of bacterial wilt caused by Erwinia tracheiphila. Lab culturing tests were not considered because current lab facilities are not adequate and extensive training would be required.

For **viral diseases**, information was provided on how to collect, dry, and send samples to Agdia (30380 County Road 6, Elkhart, IN, 46514, USA), a commercial lab capable of identifying most vegetable viruses. Although purchase of antisera and lab materials needed to identify the viruses in Swaziland was considered and explored, in my opinion, results could be obtained more economically and with more dependability from the commercial lab.

Lab Tests to Aid Diagnosis of Fungal Diseases

1. Importance of accurate diagnosis: Plant pathologists and horticulturists stress the importance of accurate diagnosis as a basis of disease control programs. In some field settings, equipment and facilities may be inadequate to allow verification of tenative diagnoses based on symptoms. This is understandable. However, whenever possible, it is important to verify field diagnoses by appropriate lab techniques.

2. Some lab procedures useful in diagnoses: Introduction: Many of the fungi that cause specific diseases on vegetables grow and reproduce on the diseased plant parts that are exhibiting symptoms. Occasionally, such fungi produce structures that can be identified without magnification, or with limited magnification with a hand-lens (5-10X magnification). However, usually it is necessary to magnify the fungus structures with a compound microscope (100-500X) to allow verification of a specific fungus pathogen. (A limited number of illustrations to help a novice mycologist identify a few selected fungi to Genus are included on following pages) When a compound microscope is available. the easiest and fastest procedure is to make a slide mount directly from diseased material when it is brought in from the field (or after a short period of refrigerated storage). Two types of slide mounts are a dry "transparent tape" mount, and a wet mount.

Dry Mounts & Wet Mounts: The dry "transparent tape" mount is easiest to prepare and therefore may be worth trying first. If diagnostic spore structures cannot be identified on such tape, it may be possible to "tease out" or "scrape off" fungus and plant material, put it into a drop of water, spread out the material in the drop of water, compress it under a cover slip,

and then observe it to search for characteristic fungus structures. If characteristic structures cannot be found on the "wet mount", try to encourage growth of the pathogen on the symptom areas by putting washed (and if necessary surface sterilized) bits of diseased tissue into a moist chamber held at room temperature for 12-72 hours. Then try the "dry mount" and "wet mount" techniques again.

Isolation & Culturing: If characteristic fungus structures cannot be found after following the above procedures, it may be necessary to surface sterilize diseased tissue, and use microbiological techniques to attempt isolation from leading edges of newly diseased plant tissue. This is a more involved and difficult procedure since special agar media (eg. potato dextrose agar) and isolation containers (petri plates) are needed, must be sterilized before use, and must be maintained in a sterile condition for 1 or more weeks. Where sterile laboratory facilities, time, and microbiology expertise (including mycology) are limiting factors, it may be wise to send diseased material to a diagnostic lab that specializes in diagnosis.

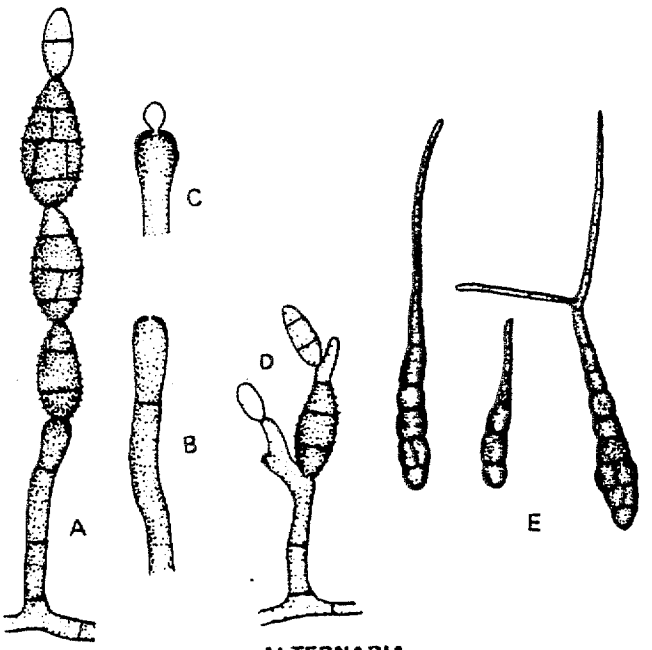
Morphological Features of Some Fungus Genera

Illustrations on the following pages may be helpful in identifying some vegetable disease-causing fungi, but only to the genus level. Since this material is prepared for those who have no prior experience with fungus identification, the genera of fungi are arranged alphabetically to facilitate ease of use. Important: Remember that these illustrations include only a few of the many fungi that cause plant disease; also, there are many more fungi that live on healthy plants, on and in refuse from plants and animals, and in soil. Therefore, I anticipate that these illustrations would be used only to verify or negate suspicion that a specific genus is involved in causing a specific disease.

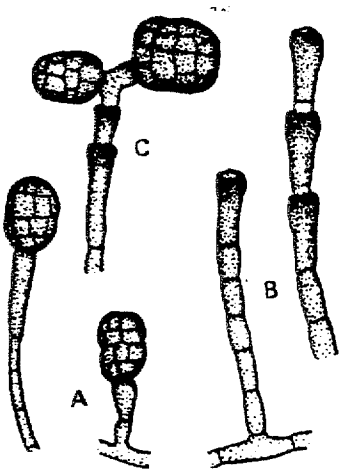
Illustrations are included for the following fungi:

Alternaria
Botrytis
Cercospora
Colletotrichum
Erysiphe
Helminthosporium
Peronospora
Phytophthora
Pythium
Rhizoctonia
Septoria
Sphaerotheca
Uromyces

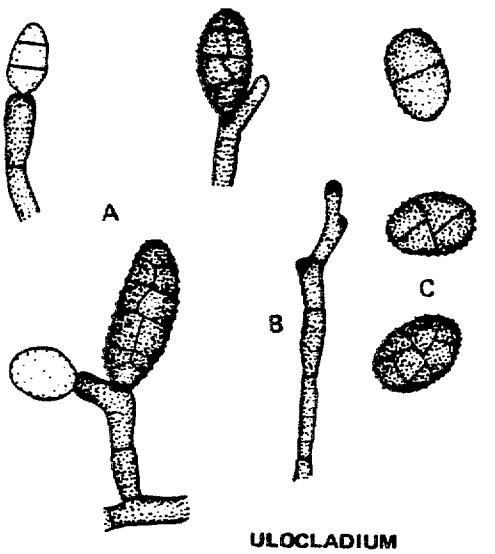
Alternaria



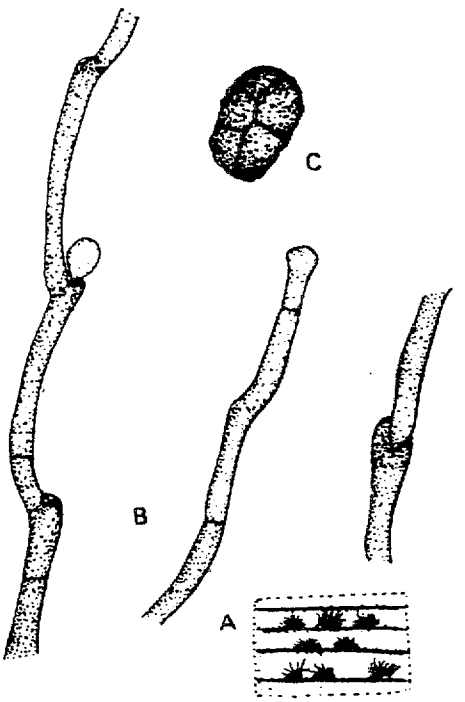
ALTERNARIA



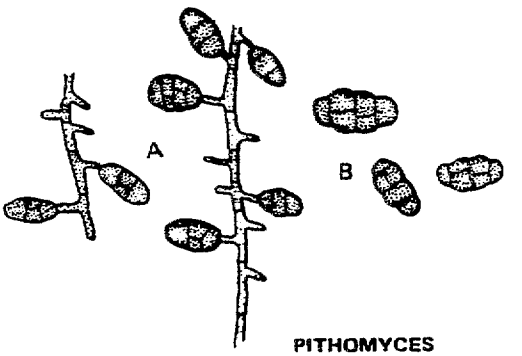
STEMPHYLIUM



ULOCLADIUM



TRICHAEGUM



PITHOMYCES

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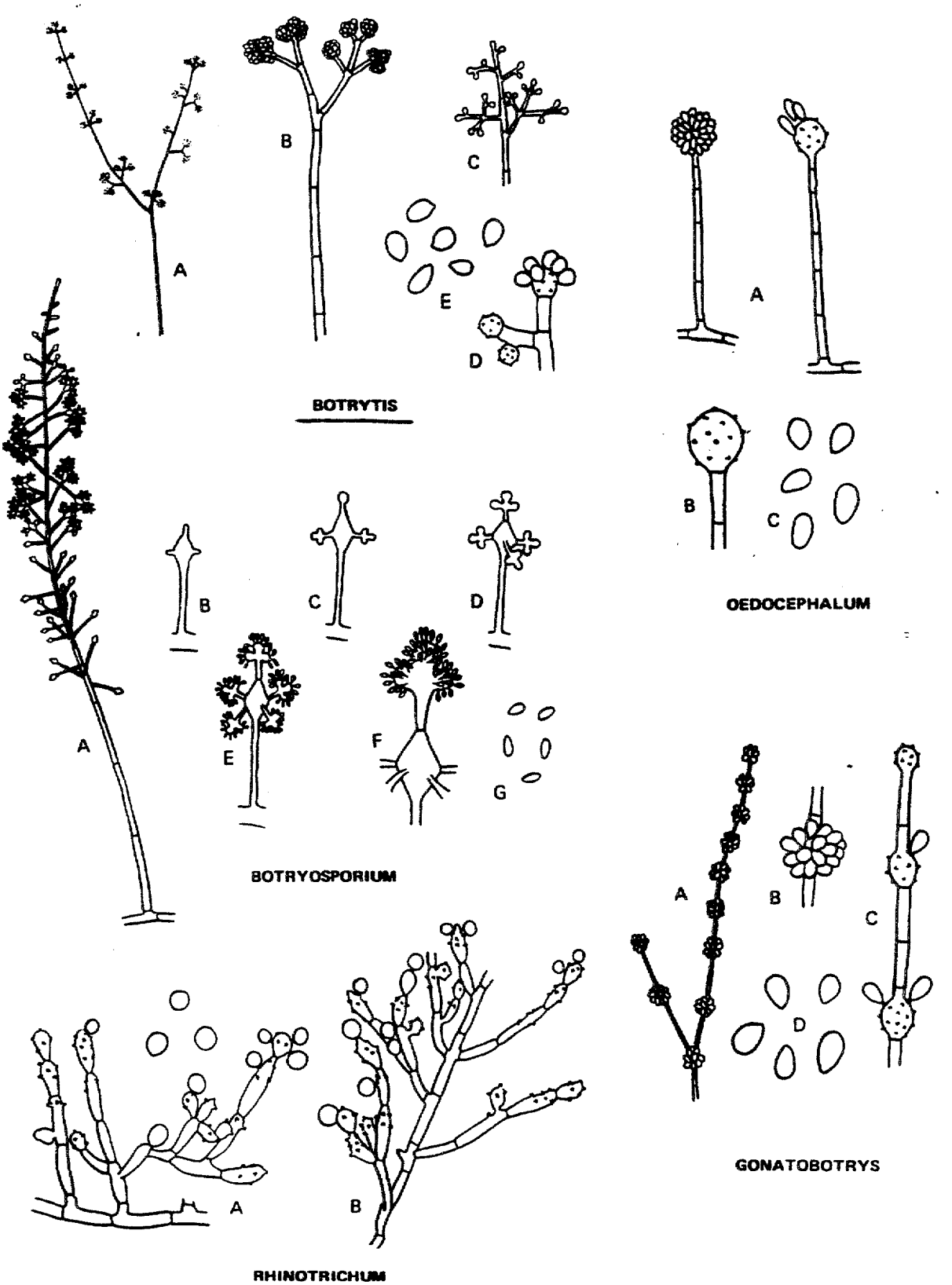
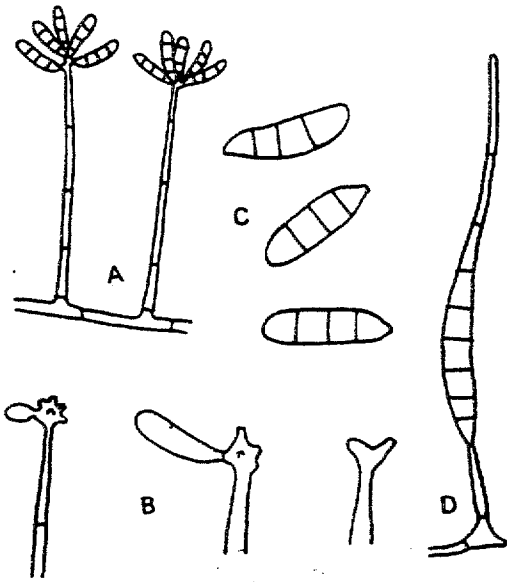
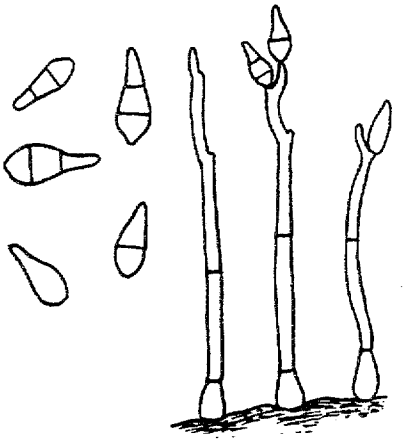
Botrytis


A
B
C
D
E
BOTRYTIS
A
B
C
OEDOCEPHALUM
A
B
C
D
E
F
G
BOTRYOSPORIUM
A
B
C
D
GONATOBOTRYS
A
B
RHINOTRICHUM

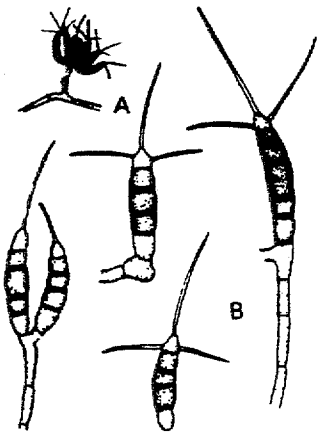
Cercospora



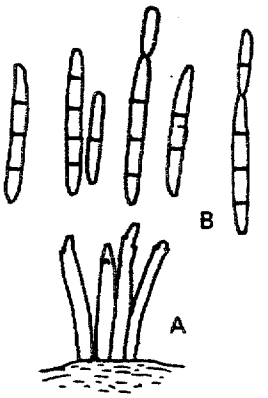
DACTYLELLA



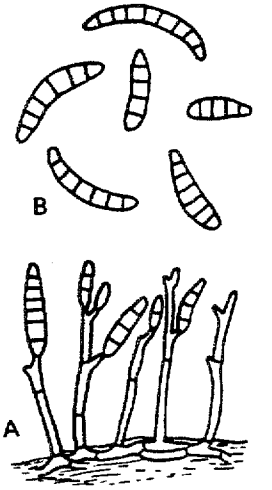
PYRICULARIA



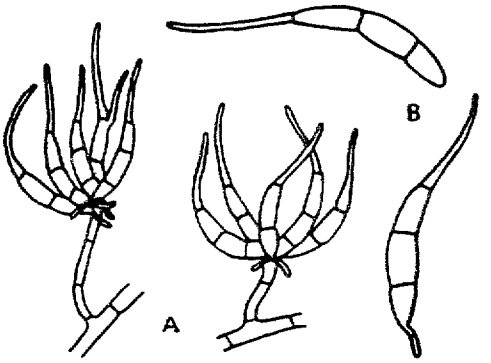
PLEIOCHAETA



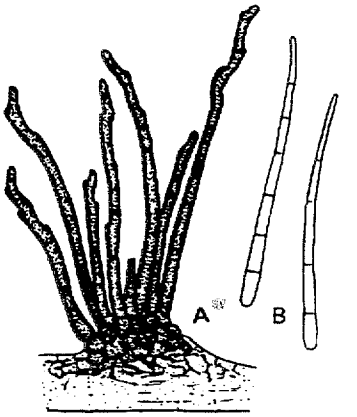
SEPTOCYLINDRIUM



CERCOSPORELLA



SPERMOSPORA



CERCOSPORA

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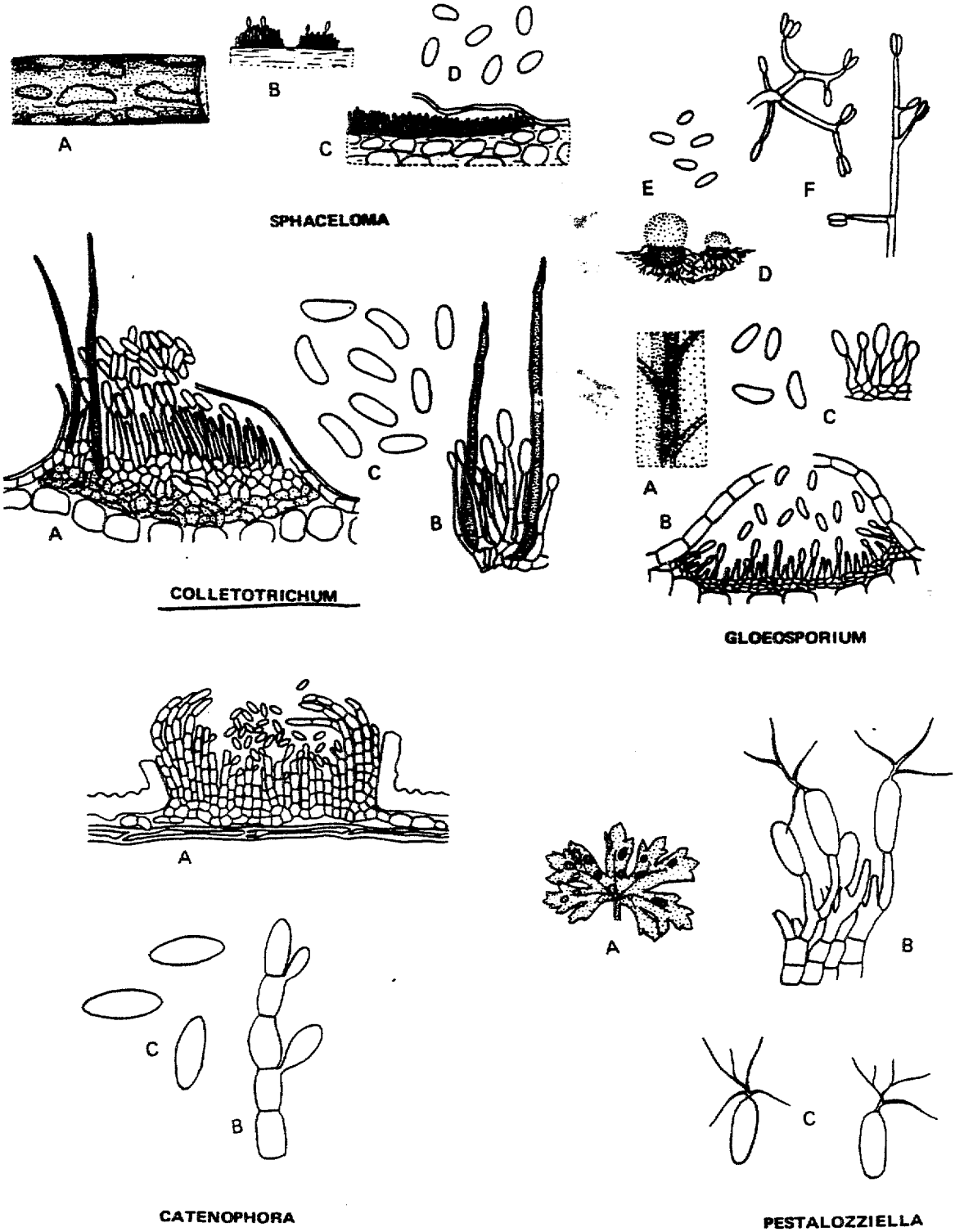
Colletotrichum



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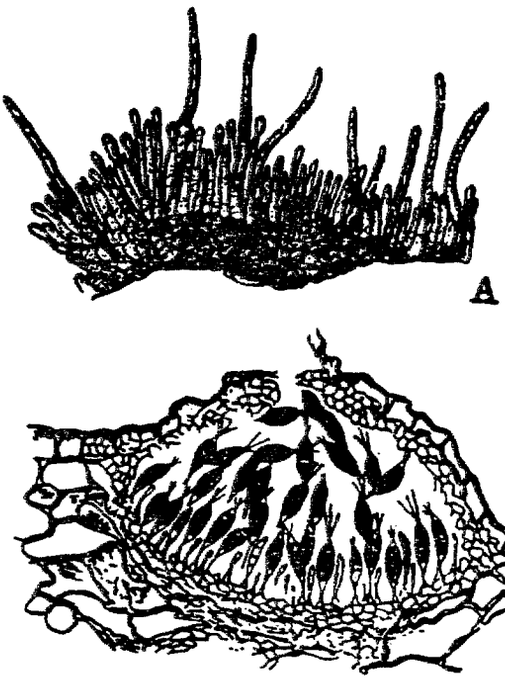
Sphaceloma (Hyalosporae) was long confused with *Gloeosporium*. Li the latter its conidia are ellipsoid and produced on short conidiophores. The acervulus differs considerably in forming a rather firm fungus cushion, in some cases almost intermediate between the sporodochium of Family Tuberculariaceae and a typical acervulus. On leaves it may cause considerable malformation. It also attacks herbaceous stems, fruits, etc.



A = Colletotrichum

FIG. 194. Melanconiales, Family Melanconiaceae. (A) *Colletotrichum malvarum* (A. Br. & Casp.) Southw. (B) *Pestalotia versicolor* Speg. (A, after Southworth: *J. Mycology*, 6(2):45–50. B, after Klebahn: *Mycol. Cent.*, 3(3):97–115.)

The perfect stage of many species has been demonstrated to belong to the genus *Elsinoë* of Order Myriangiales. Many species are destructive to economic plants.

Order Moniliales (Hyphomyceteae). This order contains 651 genera and toward 10,000 species divided into four families. The first two are distinguished by the color of the mycelium and conidiophores. The older distinction placed in the first family those genera with light-colored or bright-colored mycelium and conidiophores *and conidia*. Forms with dark-colored mycelium and conidiophores were placed in the second family, whether the conidia were light or dark, as well as forms with light-colored conidiophores but colored conidia. The author follows Bender in making the distinction as follows:

Moniliaceae: mycelium and conidiophores hyaline or bright-colored (not brown, smoky, or black), conidia hyaline or colored. These are formed on the ends of short conidiophores not distinguishable from the other branches of the

the young shoots, the buds, fruits, etc. *Sphaerotheca phytoptophila* Kell. & Swingle is found only on the lobed galls produced on the hackberry (*Celtis occidentalis* L.) by a species of mite. *Uncinula necator* (Schw.) Burr. attacks not only the leaves and young green shoots but also the immature berries of the grape (*Vitis*) while *Sphaerotheca mors-uvae* (Schw.) B. & C., on the gooseberry (*Grossularia*) is more often on the berries. The mycelium is mainly superficial, obtaining its nourishment by haustoria penetrating the epidermal cells or even to the cell layer immediately underneath. In *Phyllactinia* part of the mycelium enters the stomata and sends its

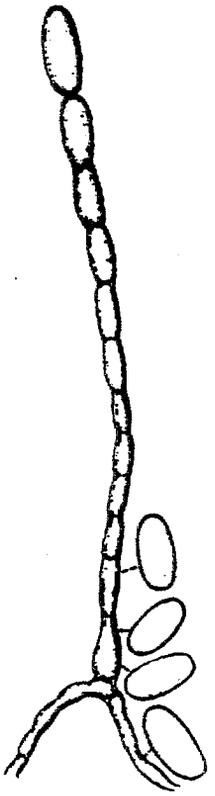
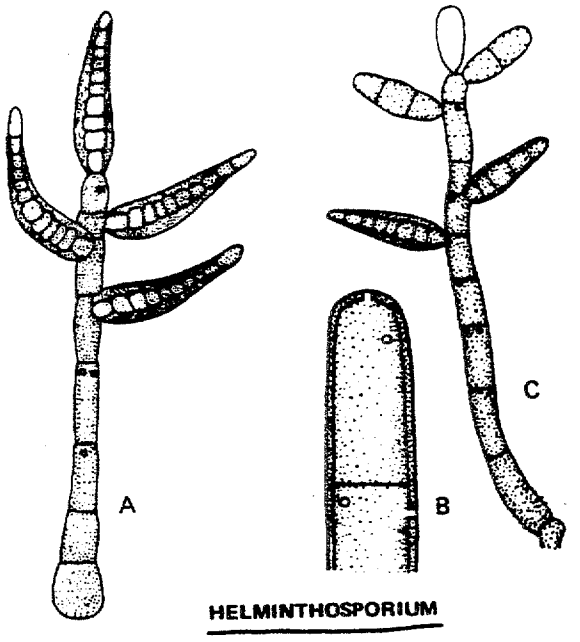


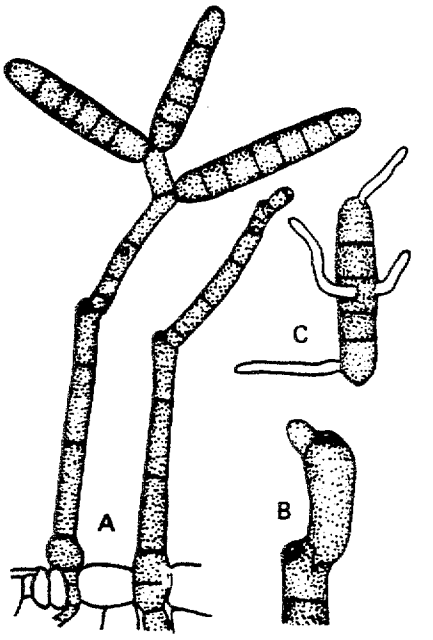
FIG. 98. Erysiphales, Family Erysiphaceae. *Erysiphe graminis* DC. Conidiophore and chain of conidia arising from surface mycelium. (After Salmon: *Mem. Torrey Botan. Club*, 9:1–292.)

haustoria into the mesophyll cells bordering the substomatal chambers. In *Leveillula* the mycelium enters the leaf through the stomatal opening and is confined to the mesophyll except that the conidiophores emerge through the stomata. Foëx (1912) pointed out that from this interior mycelium there eventually creeps out through the stomata a thin mycelium growth which spreads out over the epidermis, held fast to it by appressoria, but not producing any haustoria. This external mycelium produces the perithecia and a few conidiophores bearing short chains of small conidia which are smaller than those borne singly on the conidiophores emerging from the stomata. The mycelial cells are always uninucleate. The conidia arise at the apex of short or elongated conidiophores. In *Leveillula* and *Phyllactinia* the conidium falls off before the next succeeding conidium is formed, but in the remaining genera of the family the conidia remain attached so that a chain of conidia is produced which in

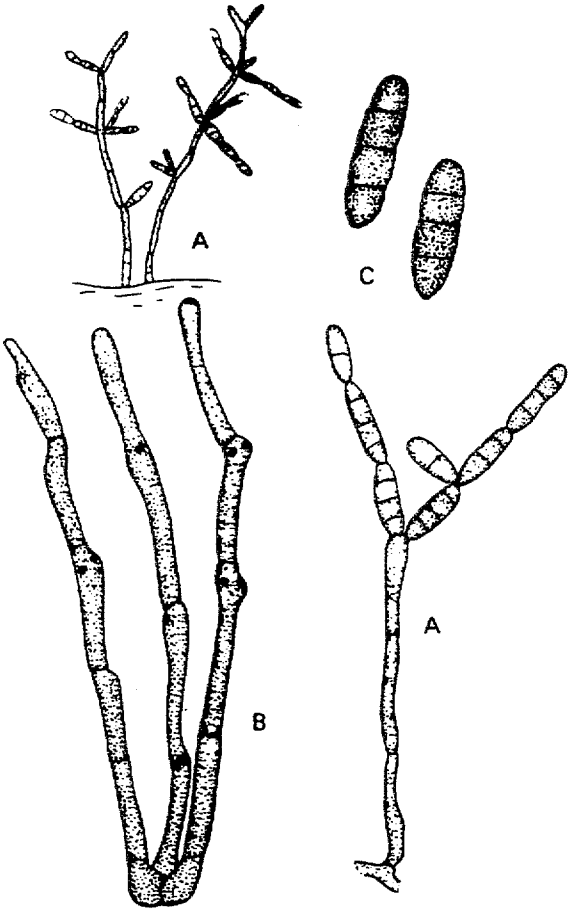
Helminthosporium



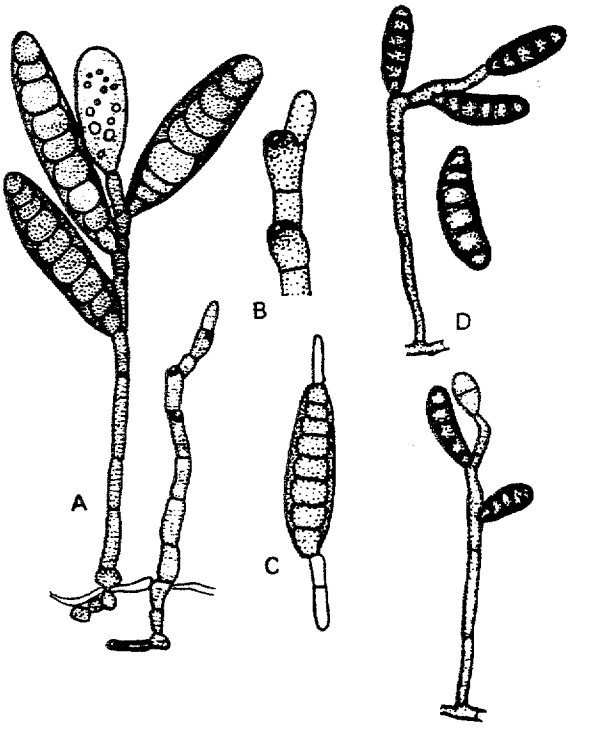
HELMINTHOSPORIUM



DRECHSLERA



DENDRYPHION



BIPOLARIS

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Peronospora

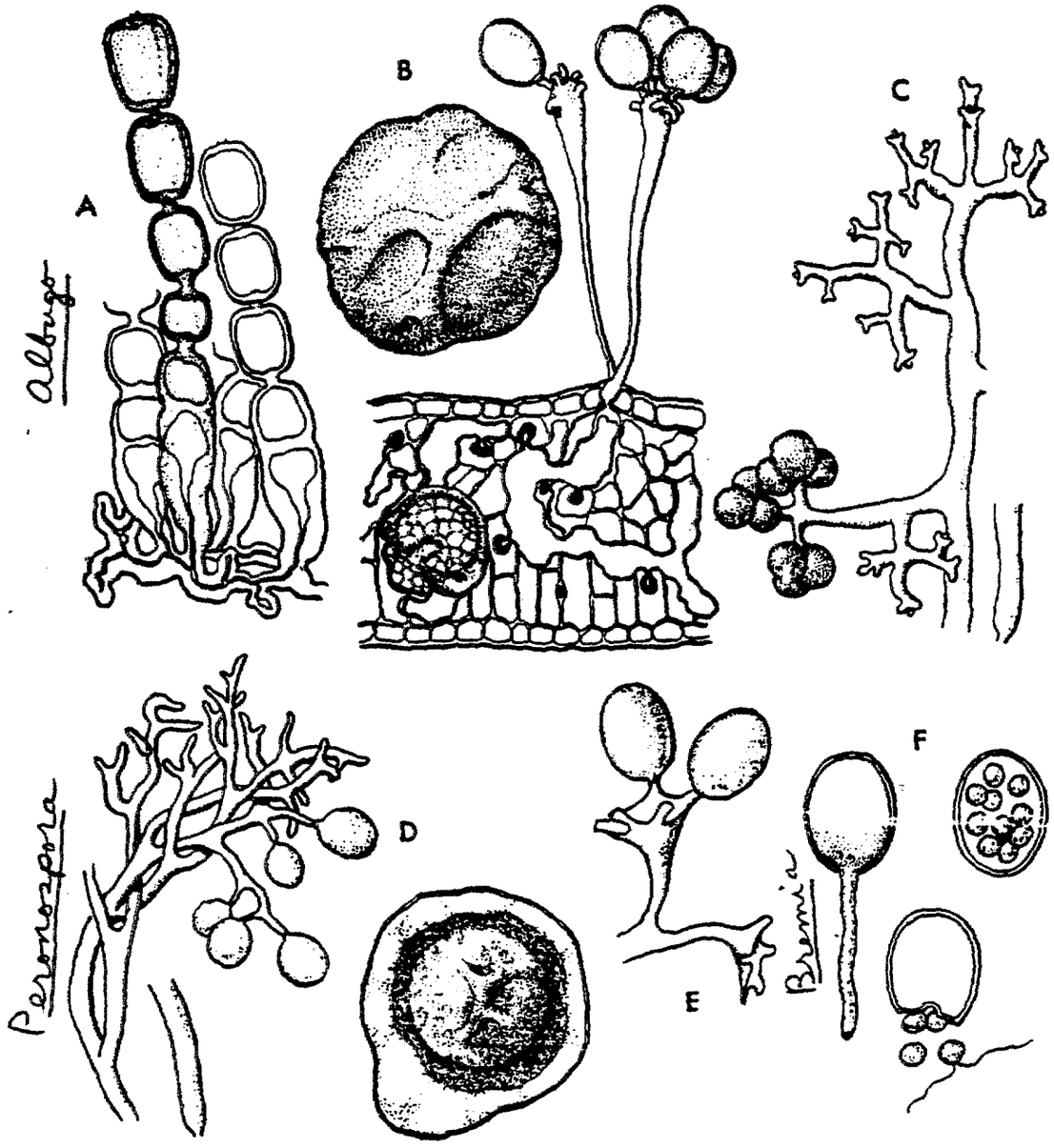

FIG. 45. Peronosporales. (A) Family Albuginaceae. *Albugo portulacae* (DC.) Kuntze. Conidiophores and conidia. (B–F) Family Peronosporaceae. (B) *Basidiophora entospora* Roze & Cornu, conidiophores and mature oospore. (C) *Rhysotheca australis* (Speg.) Wilson, conidiophore. (D) *Peronospora ficariae* Tul., conidiophore and oogone with oospore. (E–F) *Bremia lactucae* Regel. (E) Tip of conidiophore branch. (F) Conidia showing germination by germ tube and by zoospores. (A–E, after Berlese: Icones Fungorum, Padua. F, after Milbrath: *J. Agr. Research*, **23**(12):989–994.)

other composites; and *A. ipomoeae-panduranae* (Schwein.) Swing., on the sweet potato (*Ipomoea batatas* (L.) Lam.) and related plants. In most cases the disease caused is of minor importance. (Figs. 44 and 45 A.)

FAMILY PERONOSPORACEAE. The Peronosporaceae, like the Albuginaceae, differ from the Pythiaceae in their strictly parasitic habit, the mycelium always being intercellular with haustoria penetrating the ad-

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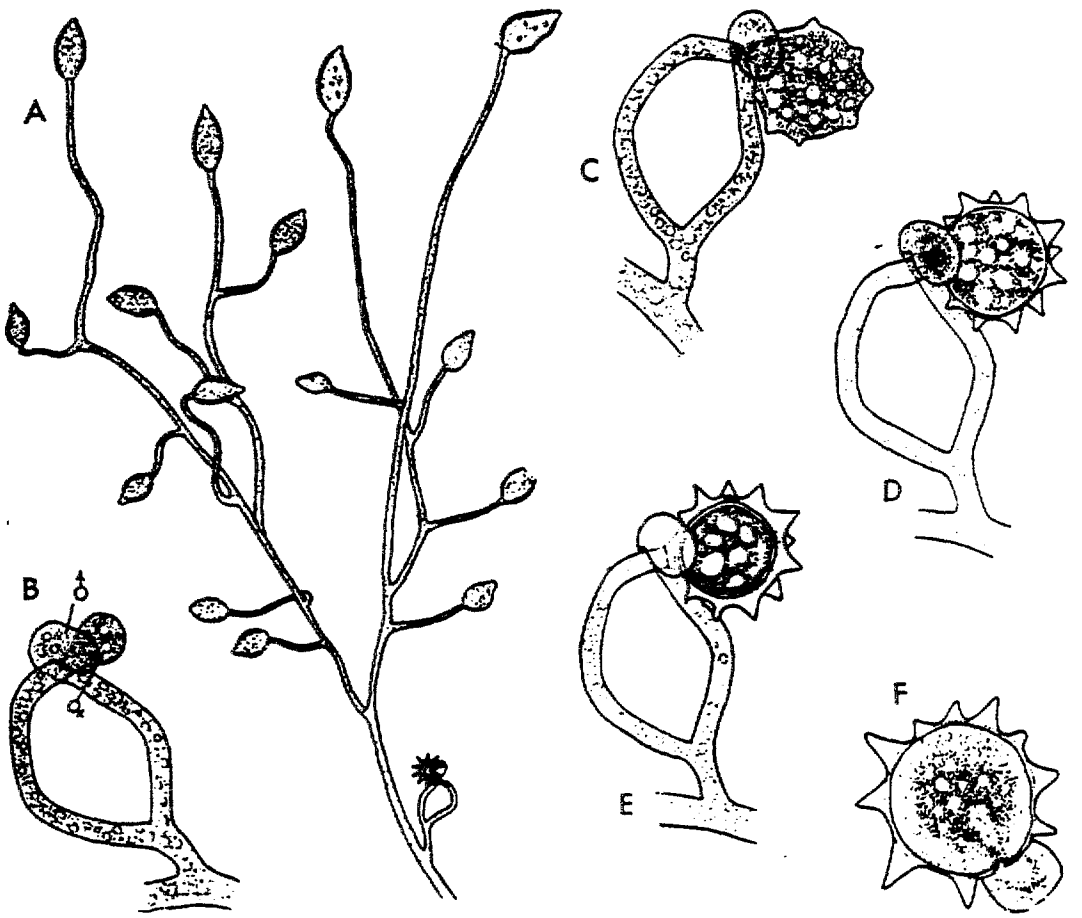

FIG. 42. Peronosporales, Family Pythiaceae. *Phytophthora stellata* Shanor. (A) Habit sketch of hypha with numerous sporangia and a sexual reproductive branch. (B–E) Successive stages in the development of the same antherid and oogone, showing possible explanation of the so-called amphigynous development. (F) Fertilization of oogone. (Courtesy, Shanor: *J. Elisha Mitchell Sci. Soc.*, **54**(1):154–162.)

Phytophthora infestans (Mont.) de Bary, the cause of the late blight of potato (*Solanum tuberosum* L.), tomato (*Lycopersicon esculentum* Mill.), and rot of potato tubers, was first observed as a serious enemy of the potato about 1845. After being studied by various investigators it was first fully described by de Bary in 1876. For many decades oogone formation was unknown in this species until Clinton in 1911 reported their production in culture on oat agar. In 1927 Murphy reported finding them on the surface of tubers and in the surrounding soil. As in some other species these oospores were mostly parthenogenetic in origin although a basal antherid was observed in one case. In *P. phaseoli* Thaxter, the oogones were shown by Clinton (1906) to be produced in the seeds while the conidiophores covered the surface of the pods of the lima bean (*Phaseolus limensis* Macf.). *P. cactorum* (L. & C.) Schröt. and some other species are troublesome rot-producing and damping-off fungi of many kinds of cultivated plants.

The border line between some of the root-inhabiting species of *Phytophthora* and some of the conidium-producing species of *Pythium* is so

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Pythium

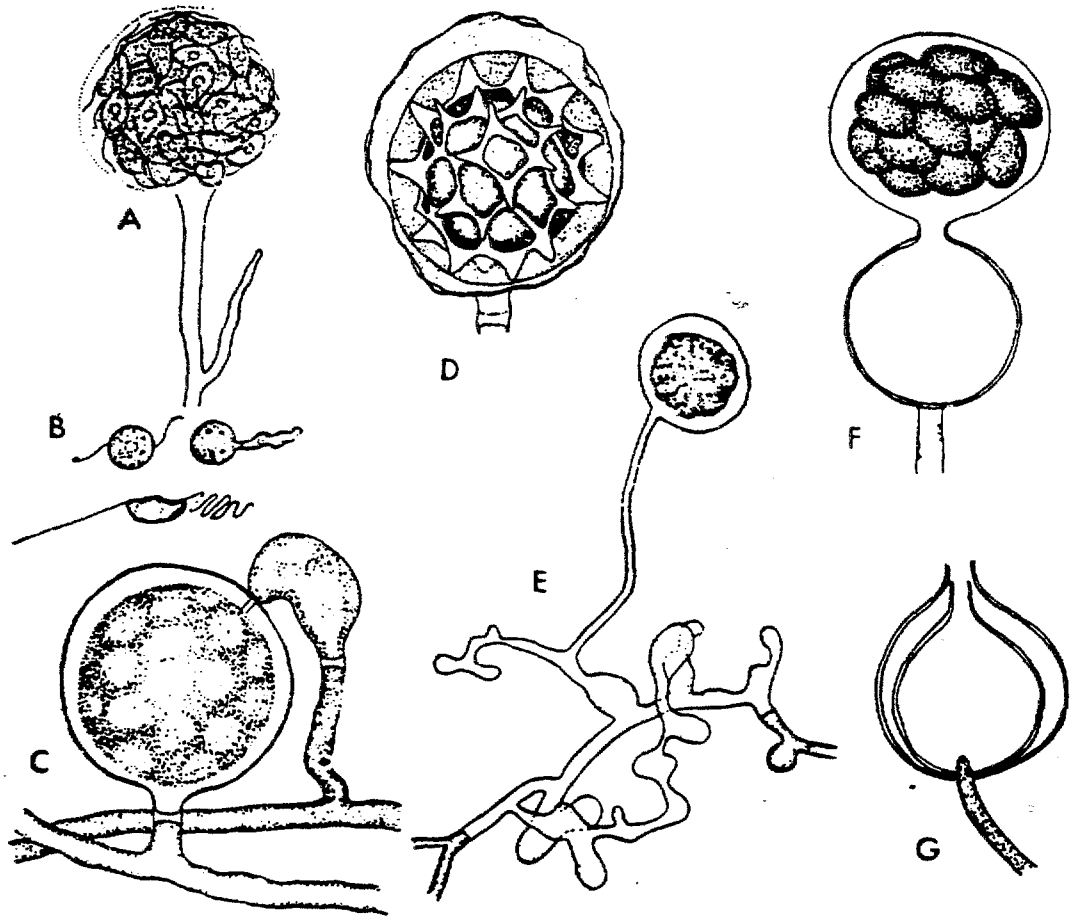

FIG. 40. Peronosporales, Family Pythiaceae. (A–D) *Pythium dictyosporum* Racib. (A) Formation of zoospores within vesicle at the open tip of the discharge tube of the filamentous sporangium. (B) Zoospores. (C) Young oogone and antherid. (D) Mature oogone and oospore. (E) *Pythium torulosum* Coker and Patterson, showing the toruloid zoosporangium and vesicle. (F, G) *Pythium proliferum* de Bary. (F) Spherical zoosporangium with vesicle. (G) Proliferated zoosporangium. (A–D, courtesy, Sparrow: *Mycologia*, **23**(3):191–203. E–G, courtesy, Matthews: Studies on the Genus Pythium, Chapel Hill, Univ. North Carolina Press.)

plants, mainly roots and stems and in one species in the leaves. In the forms parasitic in land plants the mycelium is mainly intracellular, usually killing the cells rapidly, in some cases appearing to kill them in advance of the arrival of the hyphae.

The mycelium is slender and, as in the Saprolegniales, is a branching coenocyte. Septa are formed to set off the antherids and oogones and, usually, the zoosporangia, and to separate the empty older portions of the mycelium from those containing protoplasm. Sexual reproduction has been studied by Trow (1901), Patterson (1927), Edson (1915), and others, and has been found to resemble most closely that in the Rhipidiaceae. The oogone arises terminally, less often intercalarly on longer or shorter unmodified hyphae. It is ovoid or spherical and smooth or papillate or even echinulate. Sometimes it is tubular-elongate at one or both ends. Of the several nuclei in the oogone, all but one migrate to the periphery

malorum Pk. causes twig cankers on apple and quince and the black rot of the fruits. Its perfect stage is *Physalospora*. The imperfect form genus is broken up by the more recent authors into several form genera. The name *Sphaeropsis* having been first applied to the perfect stage of an Ascomycete should, according to Petrak and Sydow, be replaced by *Haplosporella*. Some of the species usually included here they transfer to *Botryodiplodia*, including among those so transferred *S. malorum*. *Coniothyrium* has smaller pycnidia and very much smaller conidia which emerge from the ostiole in a black cirrhus. *C. fuckelii* Sacc., the cause of the cane blight of various species of *Rubus*, has as its perfect stage *Leptosphaeria coniothyrium* (Fckl.) Sacc., in the Sphaeriales. *Ascochyta* (Hyalodidymae)

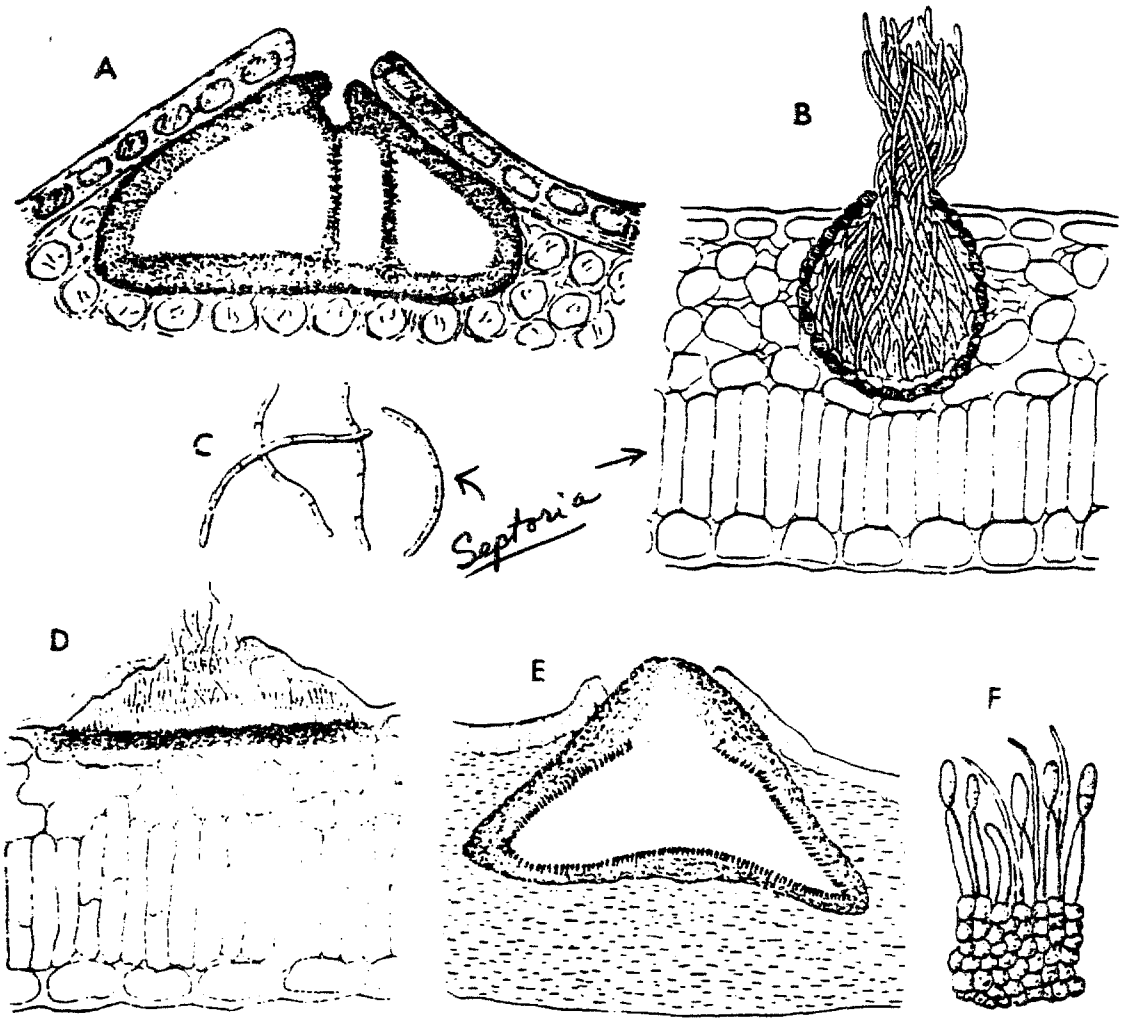

FIG. 192. Sphaeropsidales, Family Sphaeropsidaceae. (A) *Ceuthospora abietina* Delacr.; section through stroma with several pycnidial cavities with one common ostiole. (B, C) *Septoria aesculi* (Lib.) West. (B) Section through pycnidium. (C) Spores. (E–F) *Phomopsis citri* Fawcett. (E) Section through pycnidium. (F) Portion of wall of pycnidium showing pycnospores and the long, slender, curved stylospores. (D) Family Leptostromataceae. *Leptothyrium acerinum* (Kunze) Corda; section through pycnidium. (A, after Delacroix: *Bull. soc. mycol. France*, 6(4):181–184. B–C, after Briosi and Cavara: Fascicle V, No. 120. E–F, after Fawcett: *Phytopathology*, 2(3):109–113. D, after Briosi and Cavara: Fascicle II, No. 40.)

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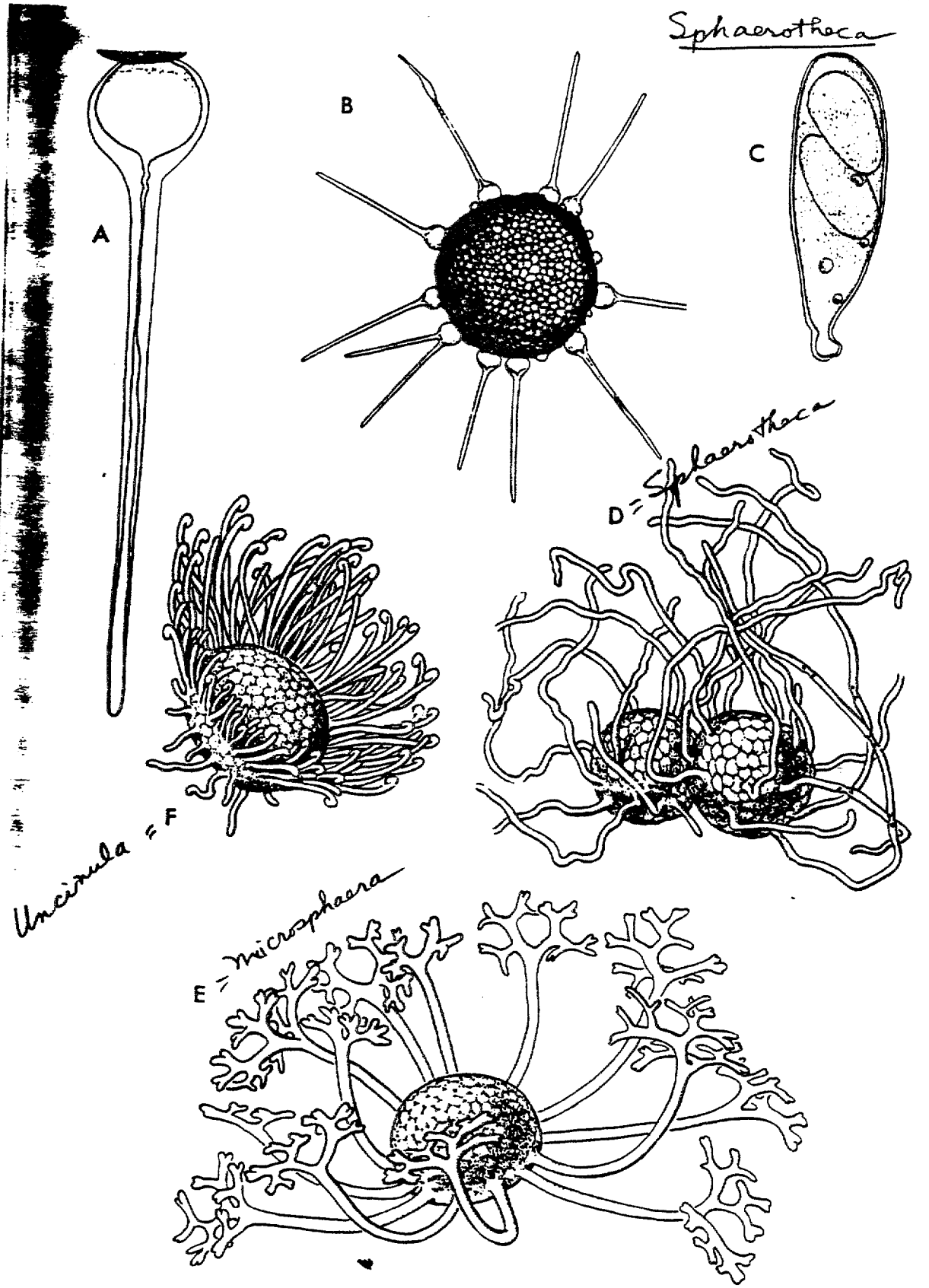

FIG. 101. Erysiphales, Family Erysiphaceae. Perithecia with various types of appendages. (A–C) *Phyllactinia eleagni* Linder. (A) Perithecial appendage, greatly enlarged. (B) Perithecium with appendages. (C) Ascus with ascospores. (D) *Sphaerotheca humuli* (DC.) Burr. Perithecia with appendages. (E) *Microsphaera berberidis* (DC.) Lev. Perithecium with appendages. (F) *Uncinula salicis* (DC.) Wint. Perithecium and appendages. (A–C, courtesy, Linder: *Mycologia*, **35**(4):465–468. D–F, after Tulasne, Selecta Fungorum Carpologia, Paris, Typographie Impériale.)

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Uromyces

Uromyces aecium

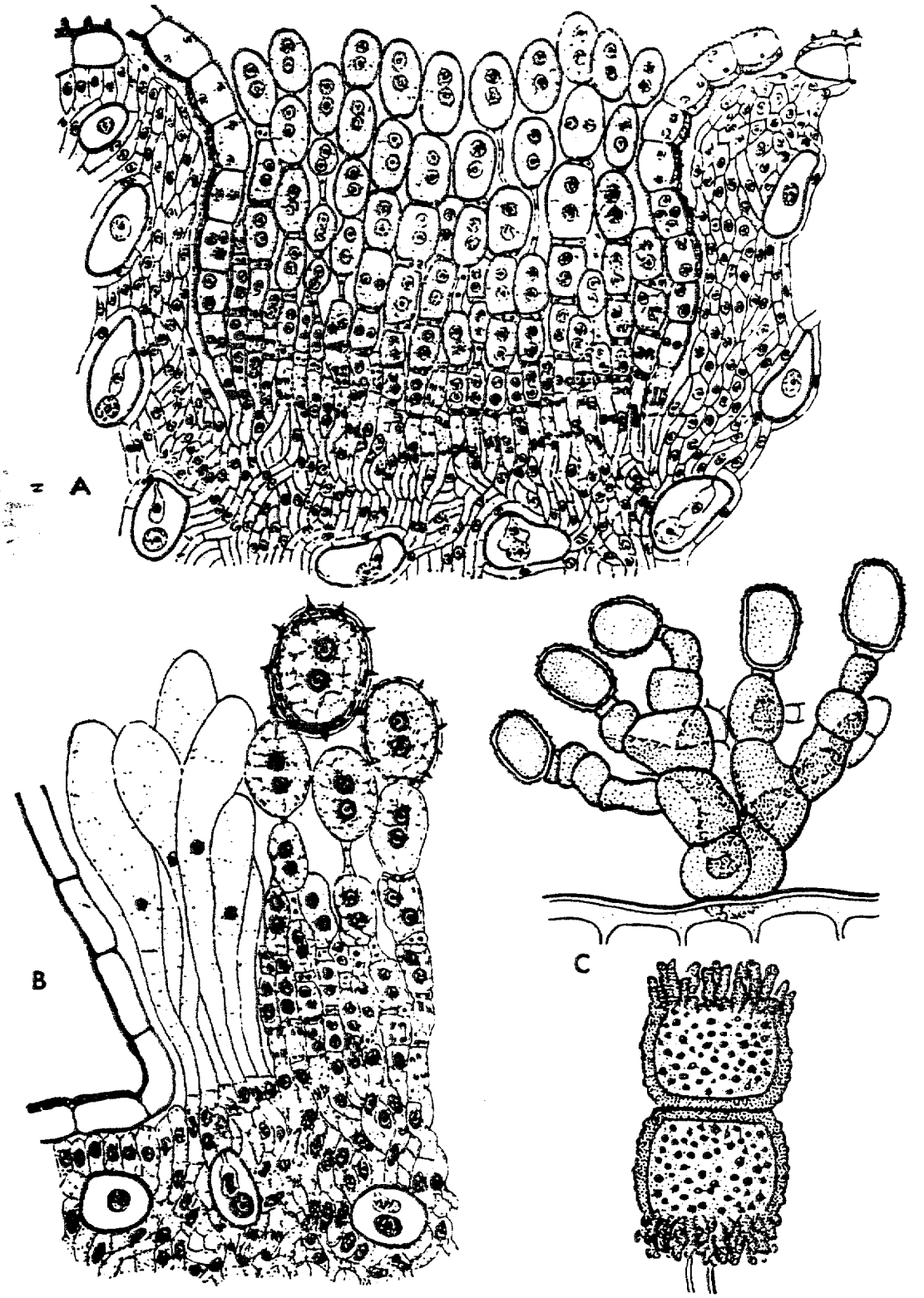

FIG. 132. Subclass Teliosporeae, Order Uredinales. Various types of aecia. (A) Cupulate aecium of *Uromyces erythronii* (DC.) Pass. (B) Margin of caeomoid aecium of *Phragmidium rubi* (Pers.) Wint., showing absence of peridium but presence of paraphysate hyphae. (C) Hyphoid aecium of *Dasyspora foveolata* B & C. and a compound teliospore. (A–B, after Sappin-Trouffy: *Le Botaniste*, 5:59–244. C, after Sydow: *Mycologia*, 17(6):255–262.)

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Uromyces

Uromyces telia

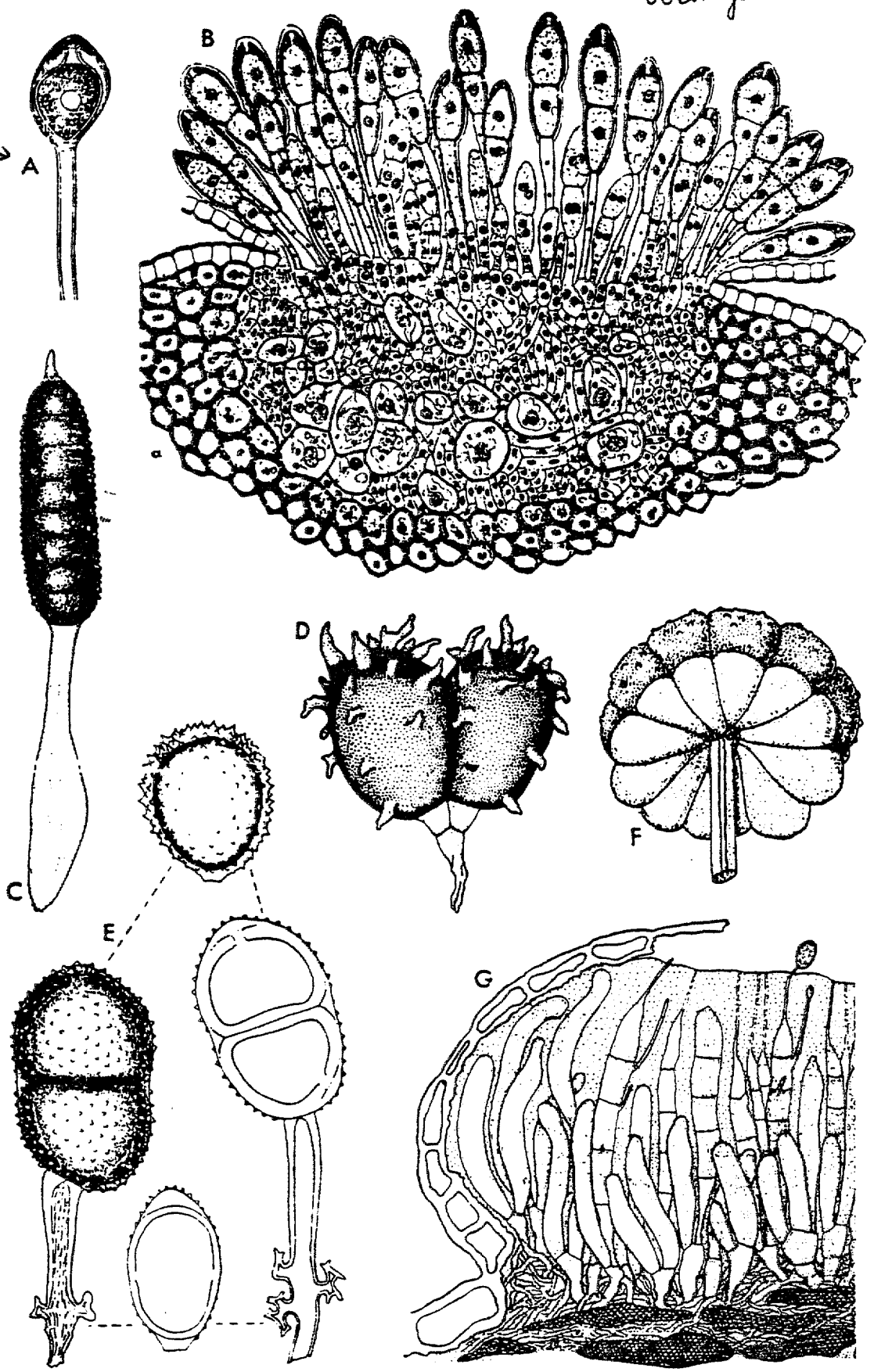

FIG. 136. Subclass Teliosporeae, Order Uredinales, Family Pucciniaceae. Various types of teliospores, all compound except *Uromyces* and *Goplana*. (A) *Uromyces fabae* (Pers.) de By. (B) *Puccinia graminis* Pers. (C) *Phragmidium rubi-idaei* (DC.) Karst.

(Continued on facing page.)

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Appendix E

Integrated Pest Management :

Snap Bean : Rust
Cabbage and Broccoli : Downy Mildew
Cabbage and Broccoli : Alternaria Leaf Spot
Sweet Corn : Common Rust
Sweet Corn : Northern Corn Leaf Blight
Corn : Maize Streak
Cucurbits : Powdery Mildew
Cucurbits : Viruses
Onion : Purple Blotch
Onion : Botrytis
Onion : Downy Mildew
Pepper : Alternaria Fruit Spot
Pepper: Anthracnose Fruit Spot
Pepper : Bacterial Soft Rot
Pepper: Cercospora Leaf Spot

What is Integrated Pest Management?

Integrated = To combine, to bring together, to consider together.

Pest = Insects, disease organisms (fungi, bacteria, viruses, nematodes), and weeds.

Management = Provide degree of control that is most efficient (economical; sustainable; not absolute unless necessary).

How? Consider all appropriate methods.

Methods considered for diseases include:

1. Rotation -- This is helpful because some pathogens starve without the crop.
2. Well-drained soil -- Some diseases are promoted by wet soil.
3. Resistance -- When possible, resistance is easy & sometimes the best control.
4. Pathogen-free seed -- Sometimes this is the most important method.
5. Parhogen-free transplants -- Almost always worthwhile; sometimes is critical.
6. Planting time -- Avoid time periods when disease is impossible to control.
7. Adjacent plantings of one crop type -- Avoid this whenever possible.
8. Control insect vectors -- Insects can be important carriers of some pathogens.
9. Avoid weedy conditions -- Weeds harbor viruses and slow drying of dew.
10. Do not work in wet plantings -- Pathogens are easily spread when wet.
11. Fungicides -- They are useful tools within an overall management program.
12. Harvest at earliest possible stage. Disease increases as leaves and fruit age.
13. After harvest, keep fruit dry and cool. Moisture and heat promote disease.
14. Kill plants soon after harvest. Pathogens reproduce and survive on old plants.

Snap Bean: Rust

Pathogen: Uromyces phaseoli (Fungus)

Plants affected: Beans.

Environment: Favored by high humidity and moderate temperatures of 18-28 °C (63-81 °F).

Symptoms: Rust pustules are most prevalent on undersides of leaves, occur sparingly on top surfaces and on pods, and are rare on stems. The pustules are first white and raised but soon turn reddish brown and later break open exposing dusty rusty spores. As many as 2000 pustules can form on one leaf. A yellowish halo frequently surrounds an area of the leaf containing one or several rust pustules in close proximity. When leaves become thoroughly rusted, they fall from the plant. During an epidemic, plants are mostly defoliated and severe yield reductions result.

Disease Cycle: Usually, the most important initial source of the pathogen is summer spores (uredospores) produced on infected bean plants either a long distance from plantings of concern, or nearby. The dry dusty spores are readily wind-borne and can be disseminated long distances by wind. Under favorable conditions, summer spores can germinate and germ tubes can enter leaves through stomate openings; new symptoms can form in 5 days. A new crop of spores can be produced every 5-10 days. Once spores are present on plants within a planting, they can be moved from plant to plant by workers, their tools, and implements. Under growing conditions that become unfavorable to the plant (eg. when hours of light is less than hours of darkness), winter spores (teliospores) are produced in the same pustules that produced summer spores. The winter spores are even more durable than summer spores and have good survival ability during times that are unfavorable for bean crop production. When environment again becomes favorable for bean culture, winter spores germinate to produce spring spores (basidiospores) that can be carried to plants by air currents, germinate on leas surfaces, infect leaves, and subsequently produce new summer spores.

Moisture: Cloudy humid days when dew persists on leaves until late in the morning are most favorable to infection; during such conditions relative humidity will be high (above 95%) for sufficient time to allow new infections to occur, and new spores to be produced. Rainfall amounts, and of sufficient intensity, to wash spores from leaves to the ground are less favorable for development of rust epidemics.

Temperature: Rust is favored by moderate temperatures of 18-28 °C (63-81 °F). If the daily temperature exceeds 33 °C (92 °F), the fungus stops growth.

Control:

1. Rotate beans with other crops; allow at least 2 years between the bean crops. Even though the summer spores can be introduced by wind, disease pressure is greater when beans are planted in a field where rust was prevalent the previous season.
2. Fungicide applications: Inspect fields weekly for presence of rust until 4 weeks before harvest. If there are at least 4 weeks left before harvest, start fungicides if an average of 2 spots per leaf are present. Continue applications at 7-day (moderate weather conditions) or 5-day (heavy dew and frequent rain) intervals.
3. When available, use resistant varieties; any resistance likely will be race specific.

Cabbage and Broccoli: Downy Mildew

Pathogens: Peronospora parasitica (fungus)

Plants affected: Crucifer family.

Environment: Long periods of wet weather favor disease.

Symptoms: In seedbeds, cotyledons and first leaves can be affected. A white mildew first develops on the underside of leaves. Shortly after the mildew is evident, a slight yellowing and sometimes a dark speckling appears on the corresponding upper surface of allected leaves. Young cotyledons and leaves, when yellow, may drop off. Older leaves usually remain attached to the plant but affected leaf areas enlarge, change from yellowish to tan, and become papery. Severely affected leaves may die. Following periods when foliage is wet and humidity is high, the white fungus is readily visible on the underside of affected leaves before the leaves die.

On cabbage heads, numerous dark sunken spots may develop on wrapper leaves. Those on the surface of outer leaves are easily visible whereas those on leaves covered by the outer wrapper leaves can be detected only when the outer leaves are pealed away. Broccoli heads invaded by the fungus usually can not be detected from their external appearance. On cauliflower heads, a black spotting and discoloration develops on the curds; in addition, dark streaks develop in the vascular tissue from affected areas down into the head and stalk.

Soft rot bacteria can enter areas of leaf tissue injured by the down mildew fungus; when this occurs, affected areas rapidly develop a wet rot and become mushy. This soft rot can occur in the field during wet periods when the crop is mature, but is most likely to develop in storage after harvest.

Pathogen Source: The fungus can survive between crops in refuse from diseased plants as thick-walled oospores, resistant structures produced by the fungus as conditions become unfavorable for growth. In areas where oospores are not present from a previous crop, the fungus can be introduced to new areas as windborne thin-walled conidia spores produced as part of the mold on affected plants in nearby areas. The conidia spores can survive wind transport for long distances in cool moist air. When spores land on susceptible plants in the cabbage family, they can germinate in 3-4 hours when conditions are favorable, and then penetrate leaves through stomates; the fungus gets food from plant cells through root-like haustoria that grow into plant cells. The fungus reproduces by producing stalks as part of the visible mold. New conidia

spores are produced on these stalks, become air-borne, and can infect other plants.

Moisture: Fog, drizzle, and dew conditions that result in plants remaining wet until 10 am for 4 days is ideal for disease development.

Temperature: Mildew develops most rapidly when night temperatures are between 8 and 16 °C (46-61 °F), and day temperatures are below 25 °C (75 °F).

Time to produce new spores: New spores can be produced 4-5 days after infection.

Control:
1. Broccoli varieties thought to have some resistance include Cindy, Citation Excalibur, and Nancy.
2. Use seedbeds not planted to a cabbage-family crop in the past 2 years.
3. Make sure seedbed areas are well drained.
4. When weather conditions favor disease development, apply protective fungicides at regular intervals to plants in seedbeds.
5. If disease persists after transplanting to production fields, protective fungicides can be used but usually are not needed unless weather conditions are especially favorable.

Cabbage and Broccoli: Alternaria Leaf Spot

Pathogens (fungi):

Alternaria brassicicola: 14-86 microns; up to 9 cells; no beak; long chains.
Alternaria raphani: 40-141 microns; up to 10 cells; short beaks; short chains.
Alternaria brassicae: 86-252 microns; up to 12 cells; long beak.

Plants affected: Crucifer family.

Environment: Need 9 hours of leaf wetness for infection to occur. Wide range of temperatures is acceptable.

Symptoms: Symptoms develop on seedling stems; young and old leaves; and heads of cabbage, cauliflower, and broccoli. On seedling stems, a dark spot can develop and result in damping-off or plant stunting. Leaf spots vary from pinpoints to 2-inches in diameter. They are most prevalent on old lower leaves. Although they begin as yellowish spots, they soon take on a black sooty appearance, with enlargement evident from distinct dark concentric rings marking zones of repeated expansion. Leaf spots may not be significant unless they are severe enough to slow plant growth, or affect the heads. Brown spots on heads, although small at first, can be numerous and/or expand considerably in favorable environment. Alternaria spots on cauliflower and broccoli also act as areas where soft rot bacteria can infect mature heads.

Disease Cycle: The fungus can be introduced with infected seed, and once present in an area, can survive between crops in refuse from diseased plants, as well as in infected perennial weeds and other plants in the cabage family. When disease is active on susceptible plants, dry conidia spores produced on affected areas can be air-borne long distances, and also can be carried by workers and their implements and tools. Time from spore germination to infection in a susceptible plant such as cauliflower can be as short as 2 days.

Moisture: Nine hours of continuous wetness is necessary for infection to occur.

Temperature: The fungus grows over a wide range of temperatures from 8-36 °C (46-97 °F).

Control:

1. Start with pathogen-free seed (eg. hot-water treated if necessary).
2. Practice rotations that avoid crucifers for as long as feasible; also control crucifer weeds since they can become diseased and serve as a "bridge" host even when cultivated crucifers are not grown.
3. Protective fungicides are useful when needed.
4. Where head rot is important on cauliflower and broccoli, avoid growing these crops near cabbage which is more susceptible and would be an important source of inoculum.

Sweet Corn: Common Rust

Pathogen: Puccinia sorghi (Fungus)

Plants affected: Corn

Environment: Favored by temperatures between 15-20 °C (59-68 °F) and at least 99% RH for about 4 hours for spore germination, and presence of dew for about 20 additional hours for infection.

Symptoms: Circular to elongate cinnamon-brown pustules form on both surfaces of leaves and husks. As a pustule develops, the epidermis becomes raised and splits open exposing cinnamon-brown powder-like urediospores (sommer spores). The color of spores in pustules may appear to change from reddish to black as black teliospores (overwintering spores) develop in the same pustule.

Disease Cycle: Disease on corn can start from two different types of spores -- aeciospores produced on oxalis, and urediospores (repeating spores) produced on corn. Where corn is grown most of the year, urediospores likely are major sources of inoculum. Although urediospores survive poorly, and therefore are unlikely to be seedborne, urediospores can survive in leaf pustules that are dry and cool. In North America, it is likely that urediospores produced during the winter and spring months are moved northward in stepwise progression involving successive plantings. Once urediospores land on a leaf, spore germination and penetration of leaves can occur within 24 hours when conditions are favorable. This infection process is favored by temperatures between 15-20 °C (59-68 °F), 99% RH for at least 4 hours, and presence of dew for about 20 additional hours. New symptoms can appear from 1 to 4 days after inoculation and pustules can occur as soon as 5 days after inoculation. Pustules appear faster at 25°C=77 °F (5 days) than at 10 °C=50 °F (16 days). The average time from infection to production of mature urediospores is 7-8 days. Secondary cycles are initiated by urediospores produced during the primary cycle. Most urediospores are released shortly after mid-day when weather is dry. Secondary cycles are promoted by warm, dry, windy periods that favor urediospore release, and by warm humid periods that favor infection. Rainfall and leaf wetness appear to inhibit spore release. Heavy rains may wash away and destroy spores in the soil.

Control:

1. Where urediospores survive on corn refuse, bury refuse by plowing; avoid no-till.
2. Where aeciospores from Oxalis are a major source of inoculum, try to control Oxalis near corn fields.
3. Where disease becomes more severe on succesive plantings, avoid locating succesive plantings in adjacent fields or strips.
4. General (multiple-gene) resistance, although only partial, likely is more useful than specific (single-gene) resistance because the single gene is race specific and many races of rust exist. General resistance in some current varieties may be useful in most fields but is not adequate during severe epidemics.
5. Protective fungicides help slow disease development; new systemic fungicides may be more effective in the future.

Sweet Corn: Northern Corn Leaf Blight

Pathogen: Helminthosporium (Exserohilum) turcicum; Races 1, 2, and 3. (Fungus)

Plants affected: Grass family including corn, sorghum, Johnsgrass, and Sudangrass.

Environment: Favored weather includes heavy and frequent rains, high relative humidity, heavy dew occurring nightly, and relatively low temperatures. Disease is checked by warm dry periods.

Symptoms: The most important type of leaf spots is referred to as the wild lesion type. These lesions are long and elliptical, straw colored initially, later grayish-green, and finally may develop a brownish margin as the spots wilt and dry out. The leaf spots can be as large as 6-inches long and 1-inch wide. Disease impact is greatest when plants are infected when they are relatively young. In sub-tropical areas, symptoms can appear at seedling stage. In temperate areas, symptoms frequently do not appear until late in the production season.

Disease Cycle: The fungus can survive from season to season as conidia spores and as clamydospores, either in soil or in association with refuse from infected plants. Survival is best under dry conditions and at temperatures below 25 °C (77 °F). Conidia spores can be transported long distances by wind. Conidia germination requires at least 90% RH, but then can occur within only 2 hours at temperatures between 16-25 °C (59-86 °F). In dew, spores can germinate in only 1 hour at 25 °C (77 °F), appressoria can form in 3 hours at 15 °C (59 °F), and infection pegs can form in 4 hours at 20 °C (68 °F). A minimum period of 6 hours at 100% RH is required for penetration. Time from inoculation to initial symptom appearance is about 1-2 days, and to appearance of typical symptoms is about 5-14 days, depending on environment. Final disease severity depends on number of life cycles completed by the fungus on the plant. When successive night temperatures are 10 °C (50 °F) or lower, chlamydospores are produced within the conidia spores; such resistant spores may be important survival structures.

Control:
1. Rotate corn with non-susceptible crops.
2. Plow under debris from infected plants.
3. Use varieties having genetic resistance. Due to presence of different races of the fungus, multigenic resistance will be more durable than the race-specific single-gene resistance.
4. When needed, fungicides can slow disease development. In Florida, yield is not affected appreciably unless defoliation exceeds 20% at

Corn: Maize streak

Pathogen (virus): Maize streak virus. Virus strains on maize differ in virulence. Some strains infect plants other than corn.

Plants affected: Maize and many other grasses.

Environment: No specific information.

Occurrence: Africa, Malagasy, and Mauritus. Reports from India are considered incorrect. As of 1994, it is not present in North America.

Economic importance: Maize streak is a major disease throughout Africa, south of the sahara desert. Losses of 100% have occurred in fields infected before plants were 7 weeks oul. Reports of the most serious disease occurrences in Africa include a 60% yield loss in Nigeria, 100% infection in some fields in Nigeria, and 88% infected plants in one 1993 field in Swaziland.

Symptoms: Early infections reduce stalk internodes, reduce leaf size, and cause ears to be poorly filled, or have non-viable seeds. On individual leaves, initial symptoms are small round, cream to white, scattered spots; these spots elongate to form discontinuous yellowish streaks parallel to veins.

Disease Cycle: The virus survives in many grasses, and also in corn wherever corn is grown or survives throughout the year. The virus is transmitted to corn and other plants by species of the Cicadulina leafhoppers. The virus does not appear to be seedborne.

Control:

1. Management practices include rogueing out plants with symptoms, providing barriers of bare ground around corn plantings, and destroying infected residues immediately after harvest.
2. Insecticide treatment by placing aldicarb or carbofuran in the seed furrow helps control leafhoppers and delays spread of disease.
3. Research is underway to develop varieties with resistance. A single recessive gene was identified in Kenya but apparently has been lost. Tolerance was found in the tropics and incorporated into maize populations. Breeding for durable resistance has been a priority. In one study, 529 maize lines, tested by seedling inoculation, were susceptible, although some variability existed in response.

Possible References:

Rose, D. J. W. 1978. Epidemiology of maize streak disease. Ann. Rev. Entomol. 23:259-282.

Sherf, A. F., and A. A. MacNab. 1986. Virus and virus-like disorders (pp.243-249, In Corn Chapter). In: Vegetable Diseases and Their Control. 728 pp. John Wiley & Sons (New York, Chichester, Brisbane, Toronto, and Singapore)

McGee, D. C. 1988. Maize Streak (p. 131-132). In Maize Diseases. 150 pp. APS press.

Cucurbits: Powdery Mildew

Pathogens: Erysiphe cichoracearum and Sphaerothecum fuliginea (fungi)

Plants affected: Cucurbit family; also papaya, African violet, and turkey mullen.

Environment: Warm, heavy dew; not dashing rains.

Symptoms: Symptoms first appear on oldest leaves. A white powdery mold appears as small circular patches on oldest leaves; the mold usually appears first on undersides of leaves but is not found until mold appears on the top top surface of leaves. The superficial powdery growth can expand rapidly and cover entire leaves within a week. Such affected leaves wither, dry up, and become brittle. Vines and fruit newly exposed to sunlight due to death of leaves may "sunburn" and become somewhat bleached. Fruit quality from severely affected plants will be of poor quality with low sugar levels.

Pathogen Source:

Usually, wind-borne spores from adjacent or distant plants that are diseased.

Conidia spores (usually); possibly ascospores produced in cleistothecia (rare).

Susceptible Leaves: Leaves are most susceptible 16 to 23 days after unfolding.

Moisture: Infection and production of new conidia is favored by high humidities near 100% although infection also can occur at remarkable low humidities (as low as 46%); however, infection can not occur when the leaf surface is wet.

Temperature: Infection and production of new conidia is favored by temperatures near 28°C (81°F), but can occur from 10 to 32°C (50 to 90°F).

Time to produce new spores: 3-7 days; longer if unfavorable weather.

Spore production level: Up to six conidia spores are produced on each fungus stalk. Over 300,000 conidia can be produced on 1 square centimeter of leaf surface.

Control:

1. Resistance: Resistance is extensively used in cucumbers and muskmelons.
2. Use sites with good air drainage and low humidity.
3. Where ditch irrigation is used, allow soil surface to dry between irrigation times.
4. Several fungicides are useful. Chlorothalonil (Bravo and Terranil), used for several other diseases, provides fair control of powdery mildew when disease pressure is light to moderate. When powdery mildew pressure is heavy, the following fungicides usually provide better control: Benzimidazoles (Benlate and Topsin) usually are effective unless they have been used exclusively and repeatedly, resulting in fungus resistance to the fungicide. Triadimefon (Bayleton) usually is highly effective. Where fungicides are needed, it may be best to alternate application of the various fungicides to minimize both expense and chance for development of resistance in the fungus to fungicides. Fixed copper applications are effective and are more economical than the organic fungicides but can be phytotoxic, especially on young cucurbits and when temperatures are high; fixed coppers may be acceptable late as final sprays on mature plants, especially when temperatures are moderate to low (less than 32 °C? (90 °F?)).

Cucurbits: Viruses

Pathogens:				
CMV	WMV-2	WMV-1	SqMV	TRSV
Transmission:				
Rubbing *Aphids	Rubbing *Aphids	Rubbing *Aphids	Rubbing *Cuke-beetle *Seed	Rubbing *Nematode
Plants affected:				
34 fam. Cucurbits Tomato Lima beans Beets Banannas Sweet corn Sw. cherry Weeds Flowers Orna-mentals Others	4? fam. Cucurbits Peas Alfalfa Vetch Clover Snow-on-the-mtn Malva parviflora Others	1 fam. Cucurbits only!	4 fam. Cucurbits Peas Coriander Salad chervil Others	54 fam. Cucurbits Papaya Lettuce Sw. potato Blueberry Soybean Clovers Snap bean Okra Rhubarb Eggplant Potato Carrot Flowers Weeds Others

Symptoms: Mosaic symptoms usually appear first on youngest leaves. Plants can be stunted. Fruit can be mottled.

Pathogen Source:

Other plants: Cucurbits, other vegetables, weeds and flowers (most viruses).
Seed and cucumber beetle (SqMV).
Contaminated aphids and worker's hands (CMV, WMV)

Plant Age and Temperature: CMV mosaic symptoms develop faster on young plants (4-5 days) than on older plants (14 days), and faster at moderate to high temperatures (26-32 °C=80-90 °F) than at higher(38 °C=100 °F) or lower (16-25 °C=60-75 °F) temperatures.

Control:

1. Resistance: Resistance is used for CMV control in cucumbers.
2. Aphid control with insecticides: In theory, aphid control would control CMV and WMV; however,spread usually is only slowed somewhat because many aphids are carrying virus from many infected weeds or other plants near cucurbit fields, and because these aphids can transmit the virus fast (30-40 seconds) before the aphids are killed by insecticides.
3. Perennial weed control near cucurbit plantings: In theory, this method would control CMV and WMV; however, it is difficult to control all potential source plants near cucurbit fields, and other cultivated plants may be additional important sources.
4. Slow aphid-borne virus spread with reflective mulch: This has been helpful until the mulch is covered by plant vines.
5. Slow aphid-borne virus spread with use of oil sprays: This method may "clean" the aphid mouth parts before they feed on a leaf. The aphids are not controlled.

Disease: Onion Purple Blotch

Cause: Alternaria porri (fungus).

Hosts: Only onion family.

Symptoms: First a sunken whitish lesion, but spots quickly turn brown. Spots enlarge and become zonate and purplish. Spot margins are reddish with a yellowish zone extending upward and downward. Leaves and seed stalks can be girdled quickly, causing them to fall over. Bulbs may be infected near harvest; affected areas turn from yellowish, to reddish, brown and finally black.

Disease Cycle: The fungus survives as mycelium in debris from diseased plants. The fungus might be introduced with seed. Dry conidia spores, produced on the mycelium, are wind borne. Most spores are produced at night when humidity is highest. As humidity drops, spores are released into the air. Spores are most prevalent between 8 am and 2 pm, with highest numbers of spores associated with windy conditions, rainfall, and movement of plants by workers. Leaves become more susceptible as they age. Rain and/or persistent dew are needed for reproduction and infection. Germination tubes enter leaves through stomates; new symptoms and spores appear in 1 to 5 days.

Control:
1. Rotation with non-related crops.
2. Plant in well drained soil.
3. Fungicide applications.
4. Sweet Spanish types are especially susceptible.

Disease: Onion Botrytis

Leaf Fleck (B. cinerea): Seldom economically important. White flecks from pectolytic enzymes produced by fungus on the external leaf surface. No ingress by the fungus on healthy tissue.

Leaf Blight (B. squamosum): Important disease. Can reduce yields by killing foliage early.

Disease Cycle: Inoculum source: Conidia from cull piles, onion debris in soil, sclerotia near soil surface, and on seed producing onions. Not ascospores. Fungus first produces enzymes on leaf surface and these cause leaf spots. Then the fungus can invade the affected leaf areas. The fungus frequently grows abundantly on the inner leaf surface, and this results in rapid whithering of affected leaves. Disease can occur with alternating environment of 16 hours light at 25 °C (77 °F) and 8 hours dark at 12 °C (54 °F). These conditions cause condensation on leaves. Condensation is necessary for infection to occur. Since optimum temperature for spore germination is 15 °C (59 °F), and optimum temperature for mycelium growth is 24 °C (75 °F), germination could occur at night and ingress/infection could occur the following day. Leaf spots result following 24 hours of 100% RH; the blight phase results at temperatures above 27 °C (80 °F). Severity increases as dew/leaf wetness periods increase. Old leaves are more severely affected than young leaves.

Controls: Reduce initial inoculum by eliminating cull piles, skipping 2-3 years between onion crops, and avoiding adjacent early and late season plantings. Slow development with fungicide sprays. Start sprays when 1 spot observed on 10 leaves.

Onion: Downy Mildew

Pathogen: Peronospora destructor (fungus)

Plants affected: Onion family

Environment: Cool and moist

Symptoms: Symptoms can appear on leaves that are at least 6-inches long. They will be most evident early in the morning when the dew is still present. A violet furry growth on leaves or seed stems is diagnostic. Infected leaves gradually become pale green, later yellow, and finally collapse and die and appear blighted. Disease symptoms frequently appear within limited areas of fields before spreading throughout a field. In wet cool environments, severe epidemics can develop. If weather turns dry, disease spread may stop and production of new leaves can result in partial recovery. Bulbs produced from affected plants may be more likely to rot during storage.

Pathogen Source:

Diseased bulbs, debris from diseased leaves, seeds, soil.
Mycelium, conidia, and oospores.

Under favorable environmental conditions, fungus mold grows on infected plant parts, and reproduces by producing short-lived conidia spores.

Favorable moisture = Dew and high relative humidity.
Acceptable temperatures = 6-27 °C (43-80 °F).
Best temperatures = 12-13 °C (52-55 °F).

Conidia release and dispersal:

Conidia are released when humidity drops.
Number of spores in air is highest early in the morning.
Conidia can be wind blown long distances from one planting to another.

Conidia can germinate on susceptible tissue in less than 2 hours at 10-12°C (50-54°F) if moisture is present. In dry weather, most conidia die without causing new infections.

New conidia spores can be produced from 11 to 15 days after infection.

When conditions become unfavorable for production of conidia spores (dry, cold, or hot), the fungus produces oospores. Oospores are thick-walled and contain a concentrated food supply. They can survive

unfavorable environmental conditions and remain viable in soil for 4-5 years.

Control:

1. Rotate to allow at least 3-years between crops in the onion family.
2. Start with healthy seed or sets; if necessary, treat seed with hot water.
3. Avoid overwintering onions or seed crops in commercial production areas.
4. Use well drained soil away from windbreaks.
5. Use protective fungicides during cool moist periods of the season.
6. Resistance: Calred has some resistance. All yellow cooking onions are susceptible.

Pepper: Alternaria Fruit Spot

Pathogen: Alternaria tenuis; Alternaria alternata (Fungus)

Plants affected: Peppers; tomatoes?

Environment: Favored by wet warm conditions.

Symptoms: Large greenish-brown to brown spots develop on fruit. These spots become covered with a dark grayish-brown to black velvety mold. These symptoms usually follow fruit injury such as that associated with blossom-end rot and sunscald. Large affected areas of fruit may have concentric dark rings that represent alternating areas of light and heavy spore production by the fungus.

Disease Cycle: The Alternaria fungus probably survives between growing seasons on debris from diseased plants, and may survive with seed. In India, the fungus enters fruit through the stigma and style.

Control:

1. Use clean seed.
2. Plant peppers only where peppers were not planted during the previous two season.
3. Kill plants as soon as possible after harvest, and plow under refuse from diseased plants if possible.
4. To minimize fruit injury and senescence, provide proper plant spacing, nutrition, and moisture conditions; avoid close and deep cultivation; control insects; avoid mehanical injury during harvesting, grading, transport, and storage.
5. When feasible, use fungicides to control foliage diseases such as anthracnose, Cercospora leaf spot, bacterial spot, and Phytophthora blight.
6. After harvest, try to keep fruit dry and as close as possible to 8 °C (47 °F); note that chilling injury can occur on fruit held between and 3 °C (32 and 36 °F).

Pepper: Anthracnose Fruit Spot

Pathogen: Colletotrichum piperatum; Colletotrichum capsici (Fungus)

Plants affected: Peppers; also marygold by Colletotrichum capsici.

Environment: Favored during periods of heavy dew, fog, and drizzle; and temperatures near 27 °C (80 °F).

Symptoms: Symptoms include damping-off, shoot dieback, leaf spot, and fruit rot. Shoot symptoms are most common on hot varieties; they start at the growing point, on flower buds, or at stem wounds, and result in branch death which spreads downward. Elongated infected stem tissue is whitish with scattered black bristly small elevations (fungus acervuli), and has distinct dark tissue between the light colored lesion and surrounding green healthy tissue. Although both can be affected, ripe fruit is more likely to be affected than green fruit. Fruit symptoms begin as small, indefinite, slightly sunken, dark yellow spots. The spots may enlarge and coalesce. Black acervuli may develop from a darkened center toward the edge of the spot. The acervuli may be arranged in concentric rings within the fruit spot. Black hairs develop on spots affected by C. capsici, but not by C. piperatum; when present, they cause the spot to become dark in color. The rot can extend to the seed cavity where it can infect seed, and cause them to turn brown.

Disease Cycle: The fungus survives in debris from diseased plants for at least one season. It can also survive on and in seed for at least 9 months; over 50% of seed from diseased fruit can be affected! When seed is affected, cotyledon leaves can become infected as they emerge from the seed. Rapid spread occurs in seedbeds, and widespread dissemination occurs via transplants. When soil is infested, the fungus can be splashed onto plant surfaces. After primary lesions appear, the fungus produces spores in acervuli within the spot. During wet conditions, the spores ooze out of the acervulus and can be splashed and blown from acervuli, and/or mechanically carried on equipment, clothing and tools to other plants. On pepper tissue, the conidia spores from acervuli germinate readily during moist conditions, and within 5 days after infection, can result in new symptoms at favorable temperatures near 27 °C (80 °F). Little disease develops at temperatures of 13 and 32 °C (55 and 90 °F). Secondary disease cycles can occur from newly produced spores.

Control:
1. Some varieties claim to have some resistance.
2. Use clean seed and disease-free transplants; hot water seed treatment may be helpful.

3. Plant peppers only where peppers, eggplants, tomatoes, potatoes and marygolds were not planted during recent seasons.
4. Plant only in well drained porous soil.
5. Spray plants in seedbeds and production fields with fungicides if necessary.
6. Avoid disease late in the season by harvesting as soon as possible and by storing the fruit at cool temperatures.

Pepper: Bacterial Soft Rot

Pathogen: Erwinia carotovora (Bacteria)

Plants affected: Pepper, tomato, potato, cabbage, lettuce, other vegetables and fruit.

Environment: Favored by rainy and wet conditions.

Symptoms: Bacterial soft rot frequently starts near the stem, at a skin puncture, or at an area injured by fruit worms. The rot spreads rapidly within a fruit until the entire fruit collapses into a soft slimy mass. Within a few days, the entire fruit can be rotted and resemble a sack of water retained by the skin. When the skin breaks, the contents flow out and the remaining skin may dry up.

Disease Cycle: Although the soft rot bacteria could be introduced with transplants, the pathogen likely is present at low levels in most fields. The soil-borne population of the bacteria can be high following presence of disease in plantings of cabbage and potatoes, and can survive from one planting season to the next. Once present in a field, the bacteria can be spread throughout a planting by insects, machinery, and workers. During the growing season, splashing water can carry the bacteria from the soil to plant surfaces where soft rot bacteria commonly are detected. When soft rot develops in fruit in the field, and periods of rainfall and wet conditions persist for long periods, the the secondary population of soft rot bacteria can be very high on plant surfaces in the field. Fruit susceptibility is increased by high moisture content, high nitrogen fertilization, hydrocooling, and jagged stem breaks. The bacteria can enter fruit only through cuts, breaks, and areas injured by insects and other agents. A high incidence of soft rot frequently is associated with harvesting during rain and washing fruit after harvest. The moisture increases the fruit susceptibility to the bacteria, which can enter newly broken stems.

Control:
1. Rotate peppers with crops such as beans, corn and soybeans; avoid rotations with potatoes and cabbage.
2. Try to prevent fruit injury by insects and other agents.
3. Harvest during dry weather.
4. During and after harvest, minimize injuries by careful handling.
5. If possible, keep fruit dry and cool during packing and storage.
6. If fruit must be washed, use wated slightly warmer than fruit temperature; it may be necessary to use clorinated wash water to prevent infection during washing.

Pepper: Cercospora Leaf Spot

Pathogen: Cercospora capsici (Fungus)

Plants affected: Sweet and hot peppers.

Environment: Favored by wet warm conditions.

Symptoms: Leaves and fruit stems are affected. Leaf spots usually are circular, have light gray centers and dark brown margins, and may be up to one-half inch in diameter. During moist conditions, the fungus can grow on the surface of leaf spots and appear as a faint dark layer over the gray leaf tissue; this may be detected by a hand-held lens. When large spots dry, they often crack, and portions of dead tissue may fall out. Severely affected leaves turn yellow and drop.

Disease Cycle: The fungus can survive at least one season in debris from diseased plants, and possibly is carried on pepper seed. Usually, first wymptoms appear about blossom time. Conidia spores are disseminated by wind, splashing rain, and on implements, tools, and workers. Spores germinate on pepper leaves during damp weather, and germ tubes enter leaves through stomates. In 7-10 days, invaded tissue dies, and new spores are produced on the spot.

Control:
1. Use clean seed.
2. Plant peppers only where peppers were not planted during the previous season.
3. Kill plants as soon as possible after harvest, and plow under refuse from diseased plants if possible.
4. Protective fungicides will reduce the rate of disease spread and development.
5. Some varieties have some resistance. (eg. California Wonder, Hungarian Wax)

Appendix F

Working Relationships with Vegetable Personnel in South Africa

Working Relationship With Vegetable Personnel in South Africa

Opportunities Related to Visit by CAPM Representatives to Roodeplaat Vegetable and Ornamental Plant Institute, Pretoria, South Africa, on March 18-19, 1994

Natal Tomato Production: Plant Pathology personnel at the Roodeplaat Vegetable and Ornamental Plant Institute, Pretoria, South Africa, indicated interest in going to Natal with Doyle Grenoble and Jobilanti Sifundza to learn about tomato production.

Strawberry Interest: Research Institute personnel indicated interest in day-neutral varieties and recognize that Doyle Grenoble has expertise in this area. This provides an opportunity for "Swaziland" to provide some assistance to South Africa.

Vegetable Production in Swaziland: Mike Kaplan, Director of Dew Crisp Farms in South Africa, has tried vegetable production in the Swaziland low veld in winter. Problems were (1) transport costs, (2) wilt of plants at first blossom stage (likely due to bacterial wilt), and (3) post-harvest diseases. Mike is willing to share information about his experiences.

Training Visit for Swazi Vegetable Farmers: Contacts at the Research Institute at Pretoria indicated willingness to help set up an opportunity for Swazi growers and industry support personnel to visit vegetable production fields and a vegetable packing building near Pretoria.

Cooperative Vegetable Trials Between Swaziland and South Africa: A key plant pathologist at the Pretoria Research Institute (Dr. Stephen Naude) indicated interest in considering joint research trials having common objectives at the Research Institute and at the Malkerns Research Station.

Resource Person for Onion Disease Information: Dr. Terry Aveling, was recently hired by the Dept. Botany and Mycology, University of Pretoria. Terry is interested in visiting Swaziland and could be a good resource for information on onion diseases and fungus identification.

Vegetable Tour in Pretoria Area: Dr. Stephan Naude, Research Institute, indicated strong interest in having current representatives from Swaziland (D. Grenoble, A. MacNab, and Jobilani Stifunzu) return to South Africa at any time to participate in a grower tour of local vegetable farms. I am certain Swazi growers would be welcomed on such a tour.

Small Farmer Needs in South Africa: As a result of the changing political situation in South Africa, a dramatic shift is anticipated in agricultural research and extension service needs. The shift will involve increasing attention on needs of small farmers. These needs are similar to those experiences by small vegetable growers in Swaziland. This provides a natural opportunity for cooperative programs by Swaziland and South Africa research and extension programs. CAPM has an excellent vegetable production guide that could be shared with South Africa. South Africa has

various publications including a special publication prepared for subsistence farmers; these likely would be useful in Swaziland.

Educational Slide Sets: Educational needs for small scale vegetable producers in Swaziland and South Africa are similar. Swazi contacts in Plant Pathology, Entomology, and Horticulture at Penn State University in the United States, provide an opportunity for Swaziland to obtain slides needed for educational programs important in Swaziland, South Africa, and other countries in Africa. This provides an excellent opportunity for the CAPM project to take the leadership in establishing and promoting cooperative projects with South Africa pathologists and horticulturists. CAPM personnel could collect slides they wanted to be included in the sets, and then have South African contact-personnel review the set and provide slides they would like added. Perhaps the CAPM project could coordinate the slide-set project, finance duplication of slides, and sell the sets at cost to cooperators; perhaps a South African contact at Pretoria University or the Vegetable Research Institute, could coordiate and finance another resource (eg. Subsistence Vegetable Production publication), and sell copies at cost to cooperators. Or perhaps certain resources could be traded without other financial arrangements. The slide-set project could build on a current set previously developed by a Swazi student when he was at Penn State.

Contact for Biological Control of Diseases: We met Dr. Lize Korsten, Plant Pathology Dept., Pretoria University, and learned about her biological control research program which appears to have considerable potential to provide control of fruit diseases in South Africa. Future attention may be expanded to include vegetable diseases.

Traditional Vegetable Production and Use: We met a new employee, Carissa Marasas (daughter of a Fusarium researcher who works with Dr. Paul Nelson at Penn State), at the Research Institute who has interest and responsibility for traditional vegetable production and use (eg. *Amaranthus* spp. collection). Doug Gamma also is interested in *Amaranthus* species, and Doyle Grenoble has information on uses for *Amaranthus*. This provides an opportunity for sharing information and establishing cooperative trials.