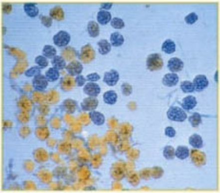
A Colour Atlas of

Post-Harvest Diseases and Disorders of Fruits and Vegetables

Volume 2: Vegetables

Anna L. Snowdon



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A Colour Atlas of

Post-Harvest Diseases and Disorders of Fruits and Vegetables

Volume 2: Vegetables

Anna L. Snowdon PhD, DIC

University of Cambridge

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Preface

In the preface to Volume 1 it is explained how for several years there was a close relationship between the University of Cambridge (Department of Applied Biology) and the UK fruit trade. Specifically, I acknowledge the part played by the National Federation of Fruit & Potato Trades in financing a long-term research and advisory post. This enabled me to carry out extensive surveys of fruit and vegetable consignments, usually in connection with legal claims arising from losses. I am especially grateful to my former research supervisor, Dr Peter Lowings, for introducing me to this world of 'forensic plant pathology'. I thank all the importers who commissioned me to survey their cargoes, and I am indebted to numerous individuals who gave of their time and expertise in the markets, ports and packing stations, both in the UK and abroad.

The book has been designed to be used in two ways. The photographs and text provide the basis for a preliminary identification, enabling the fruit owner or surveyor to assess the nature of the problem. Diagnosis can then be confirmed or modified by a specialist, making use of the microscope drawings and references together with appropriate practical techniques.

The majority of the photographs show samples of produce encountered during surveys of deteriorated consignments. A significant number show specimens received by the Plant Clinic of the Agricultural Development and Advisory Service (Ministry of Agriculture, Fisheries and Food), Cambridge, and I acknowledge with pleasure the help given by David Yarham, Michael Foley and, especially, Barry McKeown. Further plant material was kindly provided by Robert Beale, Paul Gans, Jeremy Sweet and Jane Thomas, of the National Institute of Agricultural Botany, Cambridge. Another valuable source was Dai Humphreys-Jones, who from time to time brought spectacular samples of mouldy vegetables. Excellent laboratory facilities were available in the Department of Applied Biology, under the professorship of Sir Joseph Hutchinson and later Sir James Beament. Technical advice on photography was provided by Gordon Revell, Don Manning and Bryan Barber; Allen Hilton lent his expertise in photomicrography. The remaining gaps in my slide collection were filled by borrowed photographs, for which I warmly thank the owners, acknowledged separately.

For permission to reproduce drawings from the invaluable *CMI Descriptions of Pathogenic Fungi and Bacteria* I am grateful to Professor D.L. Hawksworth, Director of the International Mycological Institute, Kew (formerly the Commonwealth Mycological Institute or CMI). Nomenclature is based on usage at the Institute, as defined in *Plant Pathologist's Pocketbook* (Ed. by A. Johnston & C. Booth, Commonwealth Agricultural Bureaux, 1983), in *Ainsworth & Bisby's Dictionary of the Fungi* (Ed. by D.L. Hawksworth, B.C. Sutton & G.C. Ainsworth, CAB International, 1983), in *Guide to Plant Pathogenic Bacteria* by J.F. Bradbury (CAB International, 1986) and in *A Dictionary of Plant Pathology* by P. Holliday (Cambridge University Press, 1989). A few synonyms are given in the text; some others may be traced via the index. For plant names and authorities, reference was made to E.E. Terrell's Checklist of Names for 3,000 Vascular Plants of Economic Importance (*USDA Agriculture Handbook* No. 505). Further information was obtained from *The Oxford Book of Food Plants* (Oxford University Press, 1969), *Evolution of Crop Plants* (Ed. by N.W. Simmonds, Longman, 1976), and J.W. Purseglove's *Tropical Crops. Dicotyledons* and *Tropical Crops. Monocotyledons* (Longman, 1968, 1972). Production data were taken from *FAO Production Yearbook* **41** (Food and Agriculture Organisation, 1988).

The text is elementary, technical terms being largely in parentheses. The aim is to provide the basic facts, with pointers to more detailed sources. No attempt has been made to recommend specific prophylactic chemicals, and local advice should be sought.

The references were chosen with the aim of including, for each main disease and disorder, a wide selection of journals, a range of countries and authors, one or two early classical papers (which are often rich in detail and illustration), together with recent reports describing current methods of control. The literature search was based on the CABI abstracting journals *Review of Plant Pathology* and (to a lesser extent) *Horticultural Abstracts*, which were scanned up till mid-1990. Holliday's *Fungus Diseases of Tropical Crops* (Cambridge University Press, 1980) was an invaluable source of key references up to and including 1978. *Post-Harvest Pathology of Fruits and Vegetables* (Ed. by C. Dennis, Academic Press, 1983) provided detailed reviews relating to temperate crops. Titles of papers in German, Dutch, French, Italian, Spanish and Portuguese have been retained in the original language; the use of English titles within square brackets denotes papers written in other foreign languages, usually with summaries in English. English summaries may in any case be consulted in the appropriate CABI abstracting journal; access is by means of the author-index or subject-index for the year in question or, more usually, the year following the reference date. For references from 1973 onwards, electronic access is also available (via the CABI database). The recent appearance of *Postharvest News and Information* (CAB Abstracts) is an indication of the increased emphasis now accorded to post-harvest studies.

Almost all of the original journals were available in the library of the Department of Applied Biology. (Following the closure of the Department in September 1989 the collection, renamed the Buttress Collection, was placed under the aegis of the Scientific Periodicals Library.) Other publications were consulted in the University Library, the Scientific Periodicals Library, and the libraries of the Botany School, the University Botanic Garden, the Shipowners' Refrigerated Cargo Research Association, Cambridge, the International Mycological Institute, Kew, and the Natural Resources Institute, Chatham. I thank all the librarians, and am especially indebted to Peter Filby for his continued interest and assistance.

I thank Awad Hassan Ahmed for help in compiling Appendix 3, which was first published in *The Storage and Transport of Fresh Fruit and Vegetables* (National Institute of Fresh Produce, 1981). The loan of facilities and equipment, by Anne Stow, Eric Miller and John Maunder, was much appreciated.

Many other generous individuals have helped me during the preparation of this book. It is not possible to mention them all, but they include Roy Burchill, Gill Butterfill, Tony Cooke, Desma Goddard, Glen Hartman, Lynn Hinton, Wilfred Hockfield, Greg Johnson, Stan Kays, Barbara Leonard, Dick Murfitt, Robert Noon, Felicity Proctor, Peter Sellar, Frederick Snowdon, Mary Snowdon, Henry Tribe, Janice Uchida, Stuart Wale, Elaine Watson and Gordon Wrigley.

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Lastly, I am indebted to Chris Hubbert and Anton Lawrencepulle for hauling me over the final hurdles, and to family and friends for their patience and support throughout.

Anna L. Snowdon
Wolfson College, Cambridge, 1991

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Abbreviations

cf.	(confer) compare
cm	centimetre(s)
cv.	cultivar
f. sp.	forma specialis (sub-division of a species of fungus)
mm	millimetre(s)
pv.	pathovar (sub-division of a species of bacterium) (below the level of subspecies)
q.v.	(quod vide) which see
sp.	species (singular)
spp.	species (plural)
ssp.	subspecies
syn.	synonym
var.	variety
°C	°Celsius (Centigrade)
°F	°Fahrenheit

CMI Descr. *CMI Descriptions of Pathogenic Fungi and Bacteria*
Published by the International Mycological Institute in sets of 10, four sets per year. Each description gives morphological details of the pathogen (including spore measurements) together with information on hosts, diseases, geographical distribution, physiologic specialization, transmission, and relevant literature.

CMI Map *CMI Distribution Maps of Plant Diseases*
Published by the International Mycological Institute and updated as necessary. Each map shows the world distribution of the pathogen, together with references to the relevant literature.

Dedicated to the memory of

Frederick A. Buttress (1908-1984)

Librarian in the School of Agriculture (which became the Department of Applied Biology), University of Cambridge. Over a period of 45 years he assembled an incomparable collection of scientific journals from all parts of the world. It was the richness of this collection which provided the inspiration for the book.

INTRODUCTORY NOTE

A general introduction to the nature and causes of post-harvest deterioration is given in Volume 1, which emphasises that the post-harvest physiology of a commodity is directly related to the biological function of the plant part. Immature organs (such as flower buds and fleshy seeds) continue in a state of high metabolic activity after harvest, and their high respiration rates mean that they cannot be expected to remain fresh for more than a brief period, even under optimal conditions. At the other extreme, storage organs (such as mature roots and tubers), by virtue of their comparatively low respiration rates, may be kept in good condition for several months. Fruits can be classified according to their respiratory behaviour as 'climacteric' (characterised by a measurable rise in respiration rate at the onset of the ripening process) or 'non-climacteric' (showing a steady respiration rate at a given temperature). Superimposed on the intrinsic differences in storage potential between various commodities there are also differences in susceptibility to diseases and disorders. Diseases are caused by infectious micro-organisms, chiefly fungi and bacteria, while disorders are the result of abnormal or undesirable physiological changes such as those caused by nutritional deficiency, moisture loss or temperature stress. The general introduction in Volume 1 outlines the factors influencing post-harvest deterioration, including pre-harvest factors, harvesting and handling techniques, and conditions during storage and transport. The importance of the plant hormone ethylene is emphasised, both in relation to its role in the ripening of climacteric fruits and in relation to its capacity for inducing premature senescence in certain vegetables.

The term 'vegetable' encompasses a range of plant parts, and the common definition is a culinary one, denoting consumption as a savoury rather than as a dessert food. Some vegetables are (in the botanical sense) fruits, for example tomatoes, peppers and eggplants in the family Solanaceae, and cucumbers, marrows and squashes in the Cucurbitaceae. These commodities are sometimes referred to as 'fruit vegetables' or 'vegetable fruits'. Another example is avocado which, however, is more usually counted among the tropical fruits (see Volume 1). Conversely, rhubarb is loosely referred to as 'fruit' solely because it is customary to add sugar and eat it as a dessert; in reality, however, it consists of vegetative parts of the plant (succulent leaf stalks), and for that reason is often considered along with vegetables. Vegetables may also be shoots (for example, asparagus), leaves (lettuce), leaf stalks (celery), flower buds (globe artichokes), inflorescences (sprouting broccoli), seed-pods (peas and beans), bulbs (onions), roots (carrots), tubers (potatoes), rhizomes (ginger) or corms (taro). In the context of post-harvest physiology this is of fundamental significance.

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1 BURTON W.G. (1982) *Post-harvest physiology of food crops.* London: Longman, 339 pp illus.
2 COOK A.A. (1978) *Diseases of tropical and subtropical vegetables and other food plants.* University of Florida: Institute of Food and Agricultural Sciences, 381 pp illus.
3 DENNIS C. (Ed.) (1983) *Post-harvest pathology of fruits and vegetables.* London: Academic Press, 264 pp.
4 DIXON G.R. (1981) *Vegetable crop diseases.* London: Macmillan, 404 pp illus.
5 ECKERT J.W. & OGAWA J.M. (1988) The chemical control of post-harvest diseases: deciduous fruits, berries, vegetables and root/tuber crops. *Annual Review of Phytopathology* **26**, 433–469.
6 PEIRCE L.C. (1987) *Vegetables: characteristics, production and marketing.* New York: John Wiley, 433 pp illus.
7 RYALL A.L. & LIPTON W.J. (1979) *Handling, transportation, and storage of fruits and vegetables. Vol. 1 Vegetables and melons.* (2nd ed.) Westport, Conn.: AVI Publishing Co., 587 pp illus.
8 SHERF A.F. & MacNAB A.A. (1986) *Vegetable diseases and their control.* New York: John Wiley, 728 pp illus.
9 WEICHMANN J. (Ed.) (1987) *Post-harvest physiology of vegetables.* New York: Marcel Dekker, 597 pp.
10 WILLS R.H.H., McGLASSON W.B., GRAHAM D., LEE T.H. & HALL E.G. (1989) *Post-harvest: an introduction to the physiology and handling of fruit and vegetables.* (3rd ed.) Oxford: Blackwell Scientific Publications, 176 pp illus.

CHAPTER 1
CUCURBITS

The family Cucurbitaceae includes a number of important crop plants. Cucumbers, marrows, squashes, pumpkins and chayote fruits are popular vegetables in many countries. Melons and watermelons are generally eaten as dessert fruits but, because of their botanical affiliations, are usually considered along with cucumbers and other close relatives (10).

The **cucumber**, *Cucumis sativus* L., is thought to have originated in India. It has been cultivated since ancient times in Asia, Africa and Europe, and was well-known to the Romans. Columbus took seeds to the Americas in the 15th century. The Spanish word for cucumber is 'pepino'; confusingly, this same word is the common name for the 'exotic fruit' *Solanum muricatum* (see Volume 1).

1 Grey mould rot of cucumber (shrink-wrapped)

The cucumber thrives in the tropics and subtropics but has also become important in cooler latitudes where it is grown under glass or plastic. World production is over 12 million tonnes, the top ten producers being China, the USSR, Japan, Turkey, the USA, Romania, the Netherlands, Poland, Iraq and Egypt.

Cucumbers are usually eaten raw as a juicy salad vegetable. (There is also a substantial pickling industry using specially bred cultivars.) The fruits are harvested physiologically immature, at which stage they seem to exhibit a non-climacteric pattern of respiration (3). This means that their rate of respiration (which is fairly low) remains roughly constant at a given temperature. Furthermore, in healthy cucumbers held at moderate temperatures there is insignificant production of ethylene gas. Cucumbers are especially prone to moisture loss and also to decay (7). Common post-harvest diseases are cottony leak, black rot and bacterial soft rot (1,7). Control depends on appropriate cultural techniques, careful handling, and sometimes the use of chemicals (7). Prompt cooling is beneficial, especially if consignments are to be shipped long distances. 'Shrink-wrapping' in polyethylene film is very effective in minimising evaporation and weight-loss; waxing is an alternative method but carries a risk of suffocation (anaerobic respiration) and increased decay (7).

Storage life of cucumbers is intrinsically rather short (7). At temperatures above about 12° or 13°C (and especially in the presence of extraneous ethylene) they lose their dark green colour within a few days and begin to turn yellow (3). On the other hand, at lower temperatures there is a risk of chilling injury (q.v.). The optimal storage temperature is a compromise and is determined by the proposed duration of storage. At 10°C and high humidity, cucumbers can be kept for about 2 weeks. A lower temperature is feasible provided that the produce is utilised before chilling symptoms become apparent. Controlled atmosphere storage can give a useful extension of storage life for 'pickling cucumbers' awaiting processing.

The **melon**, *Cucumis melo* L., comprises a range of types, the common names of which have various connotations. The three varietal names are perhaps unjustified, since all the forms hybridise readily and there are many intermediate forms.

'Cantaloupes', *Cucumis melo* var. *cantalupensis*, are characterised by a thick rough rind with regularly spaced ribs but without surface 'netting'; Charentais is a typical cultivar, having a yellowish-green, slightly ribbed skin and fragrant orange flesh. True cantaloupes are popular in continental Europe; in the USA the term 'cantaloup' is applied to muskmelons (in either of the senses of that word) (q.v.).

'Muskmelons', *C. melo* var. *reticulatus*, are green or yellow with finely netted rinds and very shallow ribs; they have a musky fragrance. In American terminology 'muskmelon' encompasses all types of *C. melo* as distinct from watermelon (q.v.). In order to avoid ambiguity it might be helpful to use the term 'netted melons' for var. *reticulatus*.

'Winter melons', *C. melo* var. *inodorus*, mature late and can be stored for several weeks. They are oval or elongated, and do not possess a strong aroma. Important cultivars include Honey Dew with smooth ivory skin and green flesh, and Tendral which has a dark green, irregularly grooved rind and yellowish-green flesh.

The place of origin of the melon is not known with certainty but the evidence points to Africa. It subsequently spread into Asia, where many new forms developed (10). Melons were not cultivated in Europe until the late Middle Ages, except perhaps in Moorish Spain. Present world production is of the order of 9 million tonnes, one quarter of which is grown in China. Other important producers are Spain, the USA, Egypt, Iran, Romania, Japan, Italy, Mexico and Iraq.

Melons are climacteric fruits but they have no starch reserves and cannot become significantly sweeter after harvest (10). Post-harvest ripening is restricted to softening of flesh and development of flavour volatiles (6). Picking is done by hand and if suitable illumination is available the work can be carried out at night rather than in the heat of the day; the benefits include enhanced retention of fruit quality and significant reduction in the cost of precooling for onward shipment. Cantaloupes and netted melons are best harvested at 'full-slip', when the fruit stalk is ready to separate naturally from the plant. At this stage they are approaching the climacteric peak, with the potential to develop full aroma (6). Harvesting at 'half-slip', when the stem-crack is still forming, allows for shipment to more distant markets yet still permits ripening to an acceptable quality. Winter melons behave in a different way and it is more difficult to judge their maturity. One indication is the changing colour of the 'ground-spot', the area of the fruit which rests on the ground. Honey Dew melons, even though harvested mature, do not necessarily have the capacity for self-ripening; in order to ensure uniform ripening in a batch of fruits it is necessary to apply ethylene treatment before shipment (6). Other post-harvest treatments may include a fungicide dip, some formulations being more effective if heated.

2 Various fungal lesions on Honey Dew melon

Prompt cooling of melons is highly desirable since it retards the breakdown of sugars (4). For netted melons the optimal temperature for storage and carriage is approximately 5°C, with a high humidity (or a plastic film wrap) to minimise moisture loss (4). Under such conditions they will keep for up to 2 weeks. Winter melons may need to be stored at 7° to 10°C. An exception is Honey Dew melons which have had the benefit of ethylene treatment; they show reduced susceptibility to chilling injury and can be held at 5°C. Some melon cultivars benefit from storage in controlled atmosphere, a 20% concentration of carbon dioxide being inhibitory to mould growth (9). This technique offers an alternative to the use of post-harvest fungicides. Common causes of deterioration in melons are fungal and bacterial blemishes and rots (2). For a detailed classical study of storage diseases of melons, see Reference 10 on page 49.

The **horned melon**, *Cucumis metuliferus* E. Mey. ex Naud., is usually classed as an 'exotic fruit', and began to receive attention only recently, first in New Zealand and subsequently in California. The fruits are oval, 10 to 15 cm long, and are characterised by numerous protuberances. On ripening, the skin turns yellow or orange but the jelly-like flesh remains green. 'Kiwano' is a patented name referring to a particular cultivar grown in New Zealand.

3 Anthracnose of watermelon

The **watermelon**, *Citrullus lanatus* (Thunb.) Matsum. & Nakai var. *lanatus*, is native to Africa. It has been cultivated in the Middle East for thousands of years. World production is currently nearly 30 million tonnes, grown mainly in China, Turkey, the USSR, Egypt, the USA, Iran, Japan, Italy, Spain and Syria. The watermelon is appreciated for its thirst-quenching properties and attractive appearance; some cultivars have yellow or orange flesh but most are deep pink with black seeds.

Until recently (Elkashif et al., 1989) it was believed that watermelons were climacteric fruits. Harvest maturity is judged on several criteria, including rind gloss and the colour of the ground-spot (10). The fruits should be cut from the plant with a sharp knife. If stem-end rot is likely to be a problem (1) it can be advantageous to disinfect the cut surface or to leave a long stalk so as to delay fungal advance into the fruit (10). Watermelons can be very large and heavy, up to about 20 kg, and even moderately sized fruits are difficult to handle without bruising (1). Small sized watermelons (between 2 and 5 kg) have recently been bred in the USA.

The optimal temperature for shipment and storage lies between 10° and 15°C, but shipment at ambient temperature is often feasible. Relative humidity is not critical, since watermelons do not readily lose moisture. They are sensitive to ethylene, however, and carriage with certain other commodities can lead to premature senescence (q.v.) of the watermelons. In the absence of ethylene they remain edible for as long as 2 or 3 months, but optimal quality is retained for 2 weeks at most.

Marrows, squashes and **pumpkins** are species of *Cucurbita*, a New World genus which has been cultivated in the Americas for several millennia, and was an important item in the diet of the Aztec, Inca and Mayan civilisations. After the Spanish Conquest seeds were carried to many parts of the globe (10). Current world production is about 6 million tonnes (this figure includes 'gourds'), grown mainly in China, Romania, Egypt, Argentina, Turkey, Italy, Japan, Syria, South Africa and Spain.

The terminology is confusing. 'Marrow' means different things in different countries. 'Squash' is an Amerindian word and is not understood as such in the UK (where the word, with a different derivation, means a fruit-flavoured drink). In North America summer squashes are the small immature fruits of *C. pepo* L., of which some cultivars are spherical or scalloped and others cylindrical, known as zucchini or courgettes in Europe. If the crop is harvested mature, the fully grown fruits are called winter squashes, an example of which is the large English 'vegetable marrow'. Other winter squashes are the mature fruits of *C. maxima* Duchesne var. *maxima*, *C. moschata* (Duschesne) Duchesne ex Poir. and *C. mixta* Pang. There is great variation, both within and between species, with respect to colour, shape and size of the fruits (10). Cultivars with coarse-grained flesh and a strong flavour are called pumpkins.

4 Cladosporium rot of summer squash

Storage conditions must take account of the fact that all are liable to chilling injury (q.v.). Cultivars differ in susceptibility. Recommendations for summer squashes vary between 7° and 10°C; at the higher temperature moisture loss is rapid (8). Chilling sensitivity can be reduced by controlled atmosphere storage, a carbon dioxide concentration of 5% permitting storage at 5°C (5). The tough-skinned mature fruits of winter squashes and pumpkins can be stored for weeks or months at moderate ambient temperatures, provided that atmospheric humidity is not excessive (10). Optimal conditions are a week or so above 20°C to permit wound-healing ('curing'), followed by storage at about 10° or 12°C and 75% relative humidity. In a study of several types of squash shipped to the New York market, bacterial soft rot was by far the commonest cause of loss (1).

The **chayote**, *Sechium edule* (Jacq.) Sw., is another New World species, and was well-known to the Aztecs (10). It is still important in Central America, and is also grown in other regions of the tropics and subtropics, including the West Indies, Australia, India and parts of Africa. Alternative names are choyote, chow-chow, cho-cho, choko and christophine, and the fruits can be boiled, stewed, fried or stuffed. They are pale green, up to 20 cm long, and shaped rather like a flattened pear with longitudinal furrows. Inside is a single large seed (which sometimes sprouts within the fruit). In order to avoid chilling injury (q.v.), chayotes should be shipped at 10° to 12°C, which confers a storage life of several weeks.

5 Black rot of chayote

The so-called **bitter cucumber** is not a true cucumber but another cucurbit, *Momordica charantia* L. The long green warty fruit is also called bitter gourd or balsam pear. It is especially common in India and the Far East. At tropical ambient temperatures it retains its quality for only a few days, while if stored or shipped at 12°C this period can be extended to 2 or 3 weeks.

1 CAPPELLINI R.A., CEPONIS M.J. & LIGHTNER G.W. (1988) Disorders in cucumber, squash, and watermelon shipments to the New York market, 1972–1985. *Plant Disease* **72**, 81–85.

2 CEPONIS M.J., CAPPELLINI R.A. & LIGHTNER G.W. (1986) Disorders in muskmelon shipments to the New York market, 1972–1984. *Plant Disease* **70**, 605–607.

3 KANELLIS A.K., MORRIS L.L. & SALTVEIT M.E. (1986) Effect of stage of development on postharvest behaviour of cucumber fruit. *HortScience* **21**, 1165–1167.

4 LINGLE S.E., LESTER G.E. & DUNLAP J.R. (1987) Effect of postharvest heat treatment and storage on sugar metabolism in polyethylene-wrapped muskmelon fruit. *HortScience* **22**, 917–919.

5 MENCARELLI F. (1987) Effect of high CO_2 atmospheres on stored zucchini squash. *Journal of the American Society for Horticultural Science* **112**, 985–988.

6 PRATT H.K. (1971) Melons. In *The biochemistry of fruits and their products* (Ed. by A.C. Hulme), pp 207–232, London: Academic Press.

7 RISSE L.A., CHUN D., McDONALD R.E. & MILLER W.R. (1987) Volatile production and decay during storage of cucumbers waxed, imazalil-treated, and film-wrapped. *HortScience* **22**, 274–276.

8 SMITTLE D.A., HAYES M.J. & WILLIAMSON R.E. (1980) Post-harvest quality changes in immature summer squash (*Cucurbita pepo* var. *condensa*). *Horticultural Research* **20**, 1–8.

9 STEWART J.K. (1979) Decay of muskmelons stored in controlled atmospheres. *Scientia Horticulturae* **11**, 69–74.

10 WHITAKER T.W. & DAVIS G.N. (1962) *Cucurbits. Botany, cultivation and utilization.* London: Leonard Hill, 249 pp illus.

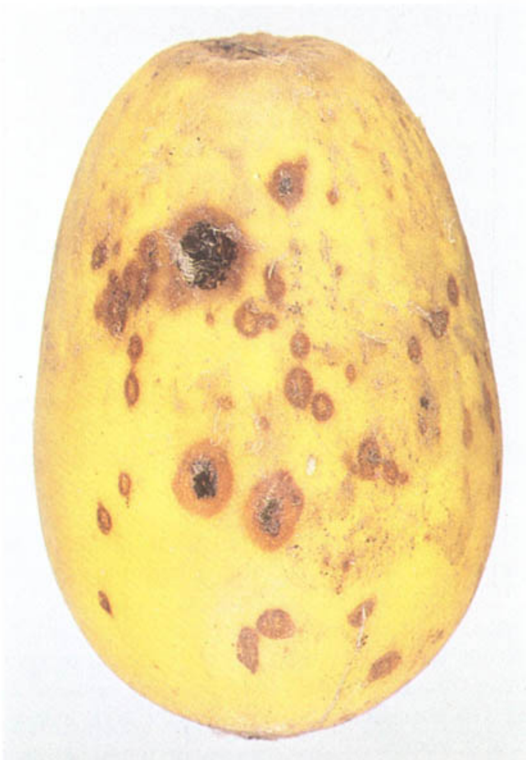
See also:

ELKASHIF M.E., HUBER D.J. & BRECHT J.K. (1989) Respiration and ethylene production in harvested watermelon fruit: evidence for non-climacteric respiratory behaviour. *Journal of the American Society for Horticultural Science* **114**, 81–85.

ALTERNARIA ROT of cucumbers, melons, watermelons, squashes and chayotes caused by

Alternaria alternata **(Fr.) Keissler**
Alternaria cucumerina **(Ell. & Ev.) Elliott**

6



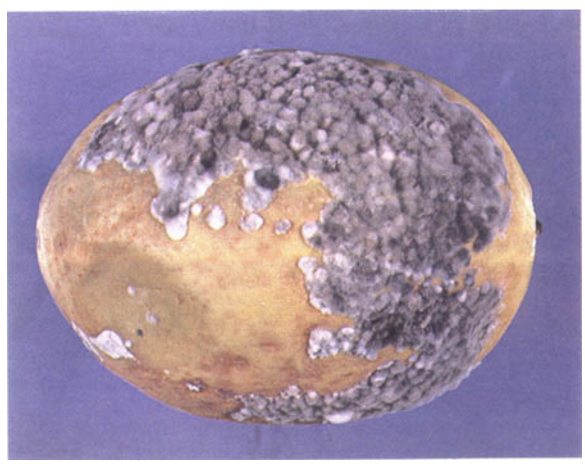
7

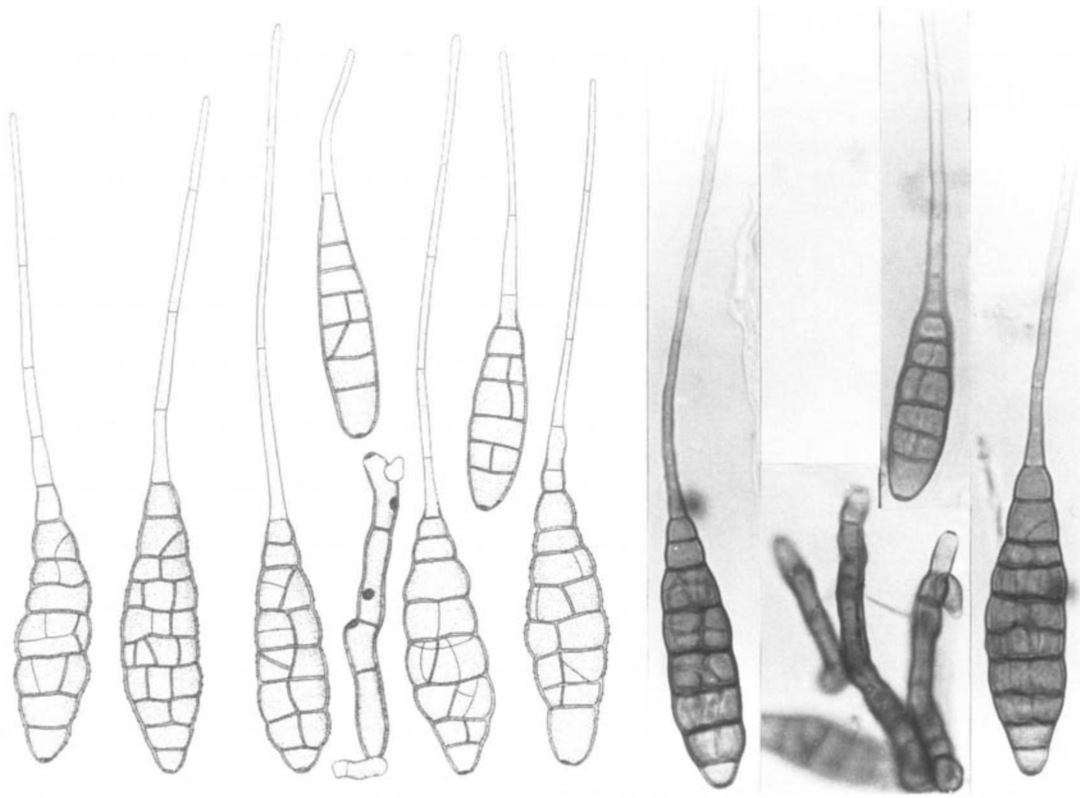
OCCURRENCE Alternaria rot probably occurs in all producing countries. *A. alternata* has been recorded on cucumbers and squashes in the USA (1,5), on melons and squashes in Israel (9), on melons in Australia (10), and on watermelons in India. *A. cucumerina* is usually more important as a cause of leaf-spot disease (3), but incidences of fruit infection have been reported on cucumbers and melons in the USA (3), melons in France (7), watermelons in Cyprus and squashes in India (2). Closely related fungi, *Stemphylium* spp. and *Ulocladium chartarum* (Preuss) Simmons, cause similar rots (4,6,8).

SYMPTOMS Lesions are circular to oval, and may become sunken. Affected skin at first appears bleached or brown but, under humid conditions, is rapidly covered by a dark mould and abundant olive-green to dark brown spores (5,7,8).

BIOLOGY The fungi probably survive in crop debris (3), and spores can be disseminated by air currents. Leaf blight caused by *A. cucumerina* can result in defoliation and exposure of fruits to the sun. Fruits weakened by sunscald are predisposed to attack by either species of *Alternaria* (3). Similarly, if fruits are stored for too long, or at too low a temperature with consequent chilling injury (q.v.), they become especially prone to alternaria decay, and suffer multiple lesions, probably centred on natural openings (stomata) in the skin (5). The author has observed such symptoms on chayotes which had been shipped from Caribbean countries at too low a carriage temperature. Species of *Alternaria, Stemphylium* and *Ulocladium* can also infect fruits through the cut stem or via injuries in the rind (6,10).

8





9 *Alternaria cucumerina* (from CMI Descr. No. 244, Ellis & Holliday 1970) Conidia and conidiophores × 500

CONTROL It may be advisable to treat the seed with a fungicide before planting (3). Control of *A. cucumerina* must be carried out during the growing season, by the use of sprays (2,7). Post-harvest decay by all these fungi can be minimised by careful handling and packing so as to prevent unnecessary injury (6), by the use of an appropriate fungicide dip (10), and by storage at an appropriate temperature (5). Fruits should not be kept for too long, especially if they have not been harvested at optimal maturity (3).

1 CEPONIS M.J. & BUTTERFIELD J.E. (1974) Market losses in Florida cucumbers and bell peppers in metropolitan New York. *Plant Disease Reporter* **58**, 558–560.
2 GANGOPADHYAY S. & KAPOOR K.S. (1973) Fruit rot of summer squash and its control. *Indian Phytopathology* **26**, 751–753.
3 JACKSON C.R. (1959) Symptoms and host-parasite relations of the Alternaria leafspot disease of cucurbits. *Phytopathology* **49**, 731–733.
4 KACHHAWAHA J.S. & ALI S.S. (1982) The relative role of extracellular enzymes during pathogenesis of *Pleospora infectoria* and *Ulocladium chartarum*. *Acta Botanica Indica* **10**, 206–209.
5 McCOLLOCH L.P. (1962) Alternaria rot following chilling injury of acorn squashes. *Marketing Research Report of the United States Department of Agriculture* No. 518, 19 pp illus.
6 MIMBELA-LEYVA L., PASSAM H.C., REILLY P.J.A. & WALLBRIDGE A. (1975) Quality problems of South American honeydew melons imported into Britain. *Tropical Science* **17**, 61–74 illus.
7 NICOLAS G. (1934) Sur un Alternaria parasite du melon. *Revue de pathologie végétale et d'entomologie agricole de France* **21**, 15–17.
8 SIMMONS E.G. (1967) Typification of *Alternaria, Stemphylium* and *Ulocladium*. *Mycologia* **59**, 67–92 illus.
9 TEMKIN-GORODEISKI N. & KATCHANSKI M. (1974) Control of storage rots of zucchini squashes by thiabendazole. *Phytopathologia Mediterranea* **13**, 172–173.
10 WADE N.L. & MORRIS S.C. (1983) Efficiency of fungicides for postharvest treatment of muskmelon fruits. *HortScience* **18**, 344–345.

ANTHRACNOSE of cucumbers, melons, watermelons, marrows, squashes, pumpkins and chayotes caused by

Glomerella cingulata **(Stonem.) Spauld. & v. Schrenk**
Conidial state: *Colletotrichum gloeosporioides* f. sp. *cucurbitae*
Glomerella magna **S.F. Jenkins & N.N. Winstead**
Conidial state: *Colletotrichum* sp.

10

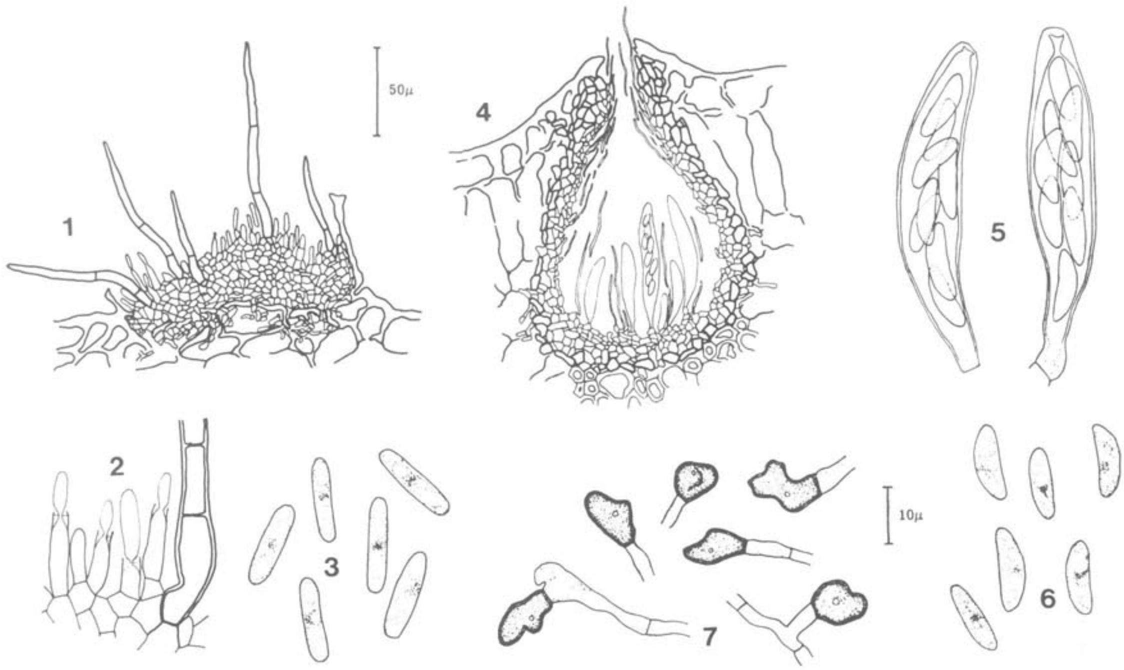
11

OCCURRENCE Anthracnose is usually caused by *Colletotrichum gloeosporioides* f.sp. *cucurbitae* (often known as *C. lagenarium* (Pass.) Ell. & Halst. or *C. orbiculare* (Berk. & Mont.) v. Arx) which can be especially virulent on cucumbers, melons, watermelons and chayotes (2,7,8). Serious losses have been reported from many countries, including the USA (3,10), Brazil (8), the Netherlands (2), India (1), Brunei (9) and Japan (6). Marrows, squashes and pumpkins are generally resistant to attack by this fungus. A related species of *Colletotrichum* (sexual state *Glomerella magna*) has been recorded in the USA on melons, watermelons, squashes and pumpkins but is of little importance on cucumbers (5).

SYMPTOMS Conspicuous dark circular spots, often very numerous, develop on the fruit surface. The lesions become sunken and sometimes cracked and, under humid conditions, characteristic masses of pinkish spores (conidia) are formed (2,3,7). Disfigurement can be severe; the common anthracnose fungus is usually confined to the skin of the fruit, though the flesh may subsequently be invaded by secondary bacteria causing a soft rot (q.v.). Lesions caused by *G. magna* may develop concentric rings, and the fungus is capable of colonising the entire fruit (5).

BIOLOGY The anthracnose fungi survive in dead plant material in field or glasshouse, when they may produce the sexual stage (perithecia giving rise to ascospores) (2,5). It is the asexual stage (acervuli giving rise to conidia) which is important in infection of the growing crop, and spores may be transmitted by insects (4) as well as by rain or irrigation water (3). Infection is particularly severe after prolonged wet periods (1), since moisture permits spore germination and direct penetration of undamaged leaves, stems and fruits (6). Disease development is rapid at temperatures between 20° and 30°C (1,7,10).

CONTROL Strict hygiene is necessary in field or greenhouse. All crop debris should be removed and destroyed, and in greenhouses any rotten woodwork should be chemically treated in case it is harbouring the fungus. It may be advisable to treat the seed before planting, as there is evidence of seed transmission (4). It has been demonstrated that disease severity can be substantially reduced by inoculating young plants with the fungus so that they acquire resistance during the early stages of growth. Fungicide sprays have proved useful against



12 *Glomerella cingulata* (from CMI Descr. No. 315, Mordue 1971) 1 acervulus 2 conidiophores 3 conidia 4 perithecium 5 asci 6 ascospores 7 appressoria

anthracnose, and disease forecasting helps to ensure that they are well-timed (1,10). Alterations to irrigation regimes can help minimise the likelihood of infection; frequent overhead sprinkling, for example, can result in epidemics (1,3,6,9). Plant breeders have investigated means of developing new cultivars (especially of cucumber and watermelon) which are resistant to the several races of anthracnose fungi which exist (10). Resistant pickling cucumbers have been bred in the USA.

1 AMIN K.S., ULLASA B.A. & SOHI H.S. (1979) Watermelon anthracnose epidemic in relation to fungicidal sprays. *Indian Journal of Agricultural Sciences* **49**, 53–57.

2 ARX J.A. von & VELDEN F.J.J.A. van der (1961) Das Colletotrichum der Gurkengewächse. *Phytopathologische Zeitschrift* **41**, 228–235.

3 GARDNER M.W. (1918) Anthracnose of cucurbits. *Bulletin of the United States Department of Agriculture* No. 727, 68 pp illus.

4 HORN N.L., WILSON W.F. & GIAMALVA M. (1957) Seed and insect transmission of cucumber anthracnose. *Plant Disease Reporter* **41**, 69–71.

5 JENKINS S.F. & WINSTEAD N.N. (1964) *Glomerella magna*, cause of a new anthracnose of cucurbits. *Phytopathology* **54**, 452–454 illus.

6 KUBO Y., SUZUKI K., FURUSAWA I. & YAMAMOTO M. (1982) Effect of tricyclazole on appressorial pigmentation and penetration from appressoria of *Colletotrichum lagenarium*. *Phytopathology* **72**, 1198–1200.

7 LAYTON D.V. (1937) The parasitism of *Colletotrichum lagenarium* (Pass.) Ell. and Halst. *Research Bulletin of Iowa Agricultural Experiment Station* No. B 223, 37–67 illus.

8 MENTEN J.O.M., KIMATI H. & COSTA C.P. (1979) Variação patogênica de *Colletotrichum gloeosporioides* f.sp. *cucurbitae* (Berk. & Mont.) n.comb. (*C. orbiculare, C. lagenarium*). *Summa Phytopathologica* **5**, 140–147.

9 PEREGRINE W.T.H. & AHMAD K. bin (1983) Chemical and cultural control of anthracnose (*Colletotrichum lagenarium*) in watermelon. *Tropical Pest Management* **29**, 42–46.

10 THOMPSON D.C. & JENKINS S.F. (1985) Influence of cultivar resistance, initial disease, environment, and fungicide concentration and timing on anthracnose development and yield loss in pickling cucumbers. *Phytopathology* **75**, 1422–1427.

BACTERIAL ROTS of cucumbers, melons, watermelons, marrows, squashes, pumpkins and chayotes

Several species of bacteria may be present in the internal tissues of healthy fruits (3). Under certain circumstances, however, bacteria can multiply and cause serious disease.

***Bacillus polymyxa* (Prazmowski) Mace** was found on Israeli melons, causing large brown spots which were sometimes hard and sometimes soft (9).

Erwinia carotovora* ssp. *carotovora (page 302) has caused soft rotting of melons grown in greenhouses in Japan, and also a watery rot of stored melons in Brazil. In the USA the same organism (under different names) was recorded on melons, squashes and pumpkins, and found to be capable of causing soft rotting in wounded cucumbers and watermelons (1,2). Insect damage and mechanical injuries predispose fruits to infection. An uneven water supply can result in cracking of fruit and bacterial invasion (2). The flesh disintegrates into a soft mass and the skin ruptures further, releasing infective juices and a foul odour.

***Erwinia ananas* Serrano** has been found on melons imported into the USA from Ecuador, Guatemala and Venezuela, as well as on melons grown in California and Texas (10). It is a yellow-pigmented bacterium and causes smooth, firm, brownish spots. These lesions are slow to develop and may remain superficial rind blemishes, but they can be up to 4 cm across and constitute a grave disfigurement. Furthermore, some strains of the bacterium are sufficiently virulent as to cause an invasive soft rot extending into the seed cavity.

***Erwinia* spp.** have often been noted on melons in the southern USA, causing dark, circular, water-soaked lesions on the skin, and numerous hard dry brown areas within the rind and also scattered in the flesh (8). In watermelons there are usually no external symptoms but, when the fruit is cut, hard brown areas are apparent within the rind. **E. herbicola** (page 240) is one of a range of bacteria which may affect watermelons in this way (3).

Pseudomonas burgeri (the name is not valid) has been reported on greenhouse cucumbers in Romania (4). Under warm humid conditions circular sunken spots form on the fruit, and the bacteria invade the vascular system, causing a soft rot of the entire fruit. Subsequent studies suggest that the organism is a virulent strain of ***Pseudomonas syringae* pv. *lachrymans***, the cause of angular leafspot and bacterial spot (q.v.).

***Xanthomonas campestris* pv. *cucurbitae* (Bryan) Dye** has caused scab-like spots on melons in Japan (7) and a severe blemish of pumpkins in Australia (5). The disease is seed-transmitted and can be controlled by treating the seed with a bactericide.

***Xanthomonas campestris* pv. *melonis* Neto, Sugimori & Oliveira** has been found in melons in Brazil (6). Small dark depressed spots coalesce to form large areas of soft watery tissue which is usually free from unpleasant odour.

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1 ARK P.A. & TOMPKINS C.M. (1938) A soft rot bacteriosis of pumpkin fruits. *Phytopathology* **28**, 350–355 illus.

2 GIDDINGS N.J. (1910) A bacterial soft rot of muskmelon, caused by *Bacillus melonis* n.sp. *Bulletin of Vermont Agricultural Experiment Station* No. 148, 363–416 illus.

3 HOPKINS D.L. & ELSTROM G.W. (1977) Etiology of watermelon rind necrosis. *Phytopathology* **67**, 961–964.

4 MARINESCU G. (1980) Recherches concernant certains aspects de biologie et lutte contre la bactérie qui produit le tâchement des feuilles et la pourriture tendre des fruits de concombres. *Bulletin de l'Académie des Sciences Agricoles et Forestières* No. 10, 103–108.

5 MOFFETT M.L. & WOOD B.A. (1979) Seed treatment for bacterial spot of pumpkin. *Plant Disease Reporter* **63**, 537–539.

6 NETO J.R., SUGIMORI M.H. & OLIVEIRA A.R. (1984) Podridão bacteriana dos frutos de melão (*Cucumis melo* L.) causada por *Xanthomonas campestris* pv. *melonis* pv.nov. *Summa Phytopathologica* **10**, 217–233 illus.

7 TAKETANI K., TAMURA M. & WAKIMOTO S. (1976) [Studies on fruit spot of Prince melon. 3. Scab-like spot caused by *Xanthomonas cucurbitae* (Bryan) Dowson.] *Proceedings of the Association for Plant Protection of Hokuriku* No. 24, 63–67.

8 THOMAS C.E. (1976) Bacterial rind necrosis of cantaloup. *Plant Disease Reporter* **60**, 38–40 illus.

9 VOLCANI Z. (1962) Occurrence of two bacterial diseases on new hosts in Israel. *Plant Disease Reporter* **46**, 893.

10 WELLS J.M., SHENG W.-S., CEPONIS M.J. & CHEN T.A. (1987) Isolation and characterization of strains of *Erwinia ananas* from Honeydew melons. *Phytopathology* **77**, 511–514.

BACTERIAL SPOT of cucumbers, melons, marrows and squashes caused by
Pseudomonas syringae **pv.** ***lachrymans*** **(Smith & Bryan) Young, Dye & Wilkie**

OCCURRENCE Bacterial spot is important in warm regions such as the central and southern USA (4,5), Israel (1) and Japan. In Italy it has caused severe losses in marrows grown under glass (2).

SYMPTOMS Typical symptoms on the fruit surface are circular, sunken, watersoaked spots which may be very numerous. The interior of the fruit may undergo a rapid soft rot, with browning of the vascular tissue (3,4,5).

BIOLOGY The organism survives on debris from an infected crop, and can also persist in the soil in the presence of crops other than cucurbits (1). The bacteria are disseminated by rainsplash or irrigation water, and cause 'angular leafspot' of the growing plant (2). Infection occurs via the natural openings (stomata) in leaves and fruits, and a bacterial exudate may ooze from the lesions (5). Under warm, moist conditions the disease spreads rapidly, the optimal temperature for bacterial multiplication being approximately 25°C. In hotter drier conditions disease development is arrested and the lesions dry out, taking on a chalky appearance. If the fruits are handled gently at harvest and marketed without delay, disease symptoms are confined to superficial disfigurement. It frequently happens, however, that fruits appear in good condition or only slightly blemished at the time of packing, but vibration suffered during the transit period precipitates rapid development of bacterial soft rot (5). Juices leak out, contaminating and infecting adjacent healthy fruits. It has also been found that this bacterium may first enter the fruit at the stem-end, as a result of injury during the growing season or via the cut stalk at harvest time (3). Soft spots on the fruit surface then result from lateral movement of bacteria outward from the invaded vascular system. Seeds are infected, thereby transmitting the disease to the next crop (5).

13

CONTROL Crop debris should be removed and destroyed, and seed treated with a bactericide before planting. Chemicals may also be applied to the growing crop (2). The likelihood of infection can be minimised by employing measures which reduce humidity within the crop, for example the use of trickle irrigation as opposed to sprinklers, or the use of hot air dehumidifiers in greenhouses. If harvested fruits show signs of infection they should be marketed locally without delay.

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1 KRITZMAN G. & ZUTRA D. (1983) Survival of *Pseudomonas syringae* pv. *lachrymans* in soil, plant debris, and the rhizosphere of non-host plants. *Phytoparasitica* **11**, 99–108.

2 MARRAS F. & CORDA P. (1973) *Pseudomonas lachrymans* (Smith et Bryan) Carsner, agente della "maculatura angolare" delle foglie e del "marciume" dei frutti dello zucchino (*Cucurbita pepo* L.). *Studi Sassaresi* III **21**, 817–827.

3 POHRONEZNY K., LARSEN P.O. & LEBEN C. (1978) Observations on cucumber fruit invasion by *Pseudomonas lachrymans. Plant Disease Reporter* **62**, 306–309.

4 SMITH M.A. (1946) Bacterial spot of honeydew melon. *Phytopathology* **36**, 943–949 illus.

5 WEBER G.F. (1929) Angular leaf spot and fruit rot of cucumbers caused by *Bacterium lachrymans* E.F.S. & Bry. *Bulletin of Florida Agricultural Experiment Station* No. 207, 32 pp illus.

BLUE MOULD ROT of cucumbers and melons caused by *Penicillium* spp.

14

OCCURRENCE Blue mould rot is a common disease of cucurbits, although published records appear to be confined to melons and cucumbers. *P. italicum* has been found on Bulgarian cucumbers (2) and *P. oxalicum* on Canadian cucumbers (4). Blue mould rot has been observed on melons from Israel (1), South Africa (3), the USA, Mexico (5), Ecuador and Peru. Species identified include *P. crustosum* Thom, *P. cyclopium* Westling, *P. pallidum* Smith and *P. viridicatum* Westling. The author has recorded *P. expansum* (page 88) on Spanish melons imported into the UK.

SYMPTOMS On melons lesions are at first circular to oval, often watersoaked and with a tendency to rupture; blue-green spores are produced in the cracks so formed, and there is a typical musty odour (5). Some strains of these fungi form restricted lesions, while others spread over much of the fruit and cause a wet collapse (3,5). In fresh cucumbers there may be multiple small circular lesions covered with spores while, in pickled cucumbers, heat-resistant enzymes produced by some species of *Penicillium* are responsible for undesirable softening of the flesh (4).

BIOLOGY Many penicillia are present in soil and in the atmosphere, and fruit is probably contaminated at the time of harvest or in the packhouse. Infection is typically via wounds or directly through skin which has been weakened by chilling injury or prolonged storage.

CONTROL Strict hygiene should be practised in field, greenhouse and packhouse. Culled fruits should be buried before blue mould can proliferate on them, and boxes used for picking should be regularly disinfected. Fruits should be handled with care so that injuries are minimised. Harvested fruits can be subjected to irradiation (1) or dipped in a fungicide (2), and should not be kept in store for too long (5).

1 BARKAI-GOLAN R., KAHAN R.S. & TEMKIN-GORODEISKI N. (1968) Sensitivity of stored melon fruit fungi to gamma irradiation. *International Journal of Applied Radiation and Isotopes* **19**, 579–583.
2 GEORGIEVA M. & KOTEV S. (1977) [Rot of cucumber fruits during transportation and its control.] *Bulgarski Plodove, Zelenchutsi i Konservi* No. 6, 23–26.
3 RATTRAY J.M. (1939) In *Report of the Low Temperature Research Laboratory, Cape Town, 1937–1938*, pp 55–65.
4 RAYMOND F.L., ETCHELLS J.L., BELL T.A. & MASLEY P.M. (1959) Filamentous fungi from blossoms, ovaries, and fruit of pickling cucumbers. *Mycologia* **51**, 492–511.
5 WIANT J.S. (1937) Investigations of the market diseases of cantaloups and Honey Dew and Honey Ball melons. *Technical Bulletin of the United States Department of Agriculture* No. 573, 47 pp illus.

BOTRYODIPLODIA ROT of cucumbers, melons, watermelons, squashes and pumpkins caused by ***Botryodiplodia theobromae*** **Pat.**

15

OCCURRENCE This disease, formerly known as diplodia rot, can cause serious losses in warm regions such as the southern USA (1,4), Chile (5), India (2) and Egypt (3).

SYMPTOMS Lesions are initially buff-coloured, and the affected area is spongy with a water-soaked margin (5). Dark grey mould strands may develop on the surface. The fungus also produces a tough layer beneath the skin of the fruit, causing it to become severely wrinkled. Minute black bodies (pycnidia) are usually produced, and a sour odour accompanies the decay. Lesions may occur anywhere on the fruit, but are frequently found at the stem-end (1,4). Invasion of the seed-cavity results in blackening of the seed (2). Cucumbers, melons and watermelons tend to undergo a dry rot, but pumpkins suffering from this disease become soft and lose their shape (3).

BIOLOGY The fungus, which is common in soil and on crop debris, exists in the asexual state (pycnidia giving rise to conidia) and the spores are dispersed by wind and water (page 371). The growing crop may suffer from stem blight (1,3), with symptoms indistinguishable from those caused by *Didymella bryoniae* (q.v.). Fruits can only be infected via a wound (5), including that made by cutting the stem at harvest (1). The optimal growth temperature for the fungus is approximately 30°C and it grows scarcely at all below 10°C (5).

CONTROL It may be necessary to use a fungicide spray on the growing crop (1). Irrigation should be carefully controlled (3). Care should be taken to minimise injury during harvesting and handling, and a post-harvest fungicide should be applied, either as a paste on the cut stem (5) or as a dip to protect the whole fruit. This fungus can be effectively held in check by refrigeration.

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1 BERAHA L., TOWNER D.B. & CAMP T.H. (1976) Stem gumming and blight and stem end rot of Texas cantaloups caused by *Diplodia natalensis*. *Plant Disease Reporter* **60**, 420–422 illus.

2 MAHOLAY M.N. & SOHI H.S. (1982) *Botryodiplodia* seed rot of bottlegourd and squash. *Indian Journal of Mycology and Plant Pathology* **12**, 32–36.

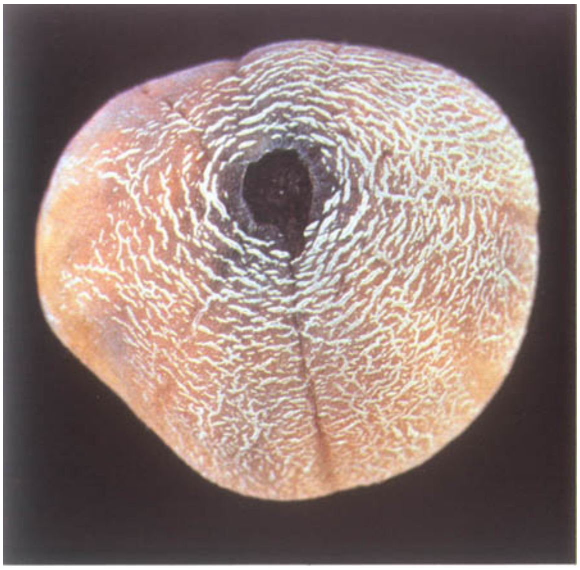
3 SATOUR M. & SHINNAWY S. (1977) *Botryodiplodia* fruit rot of pumpkin in Egypt. *Agricultural Research Review* **55**(2), 113–115.

4 TAUBENHAUS J.J. & EZEKIEL W.N. (1934) Stem-end rot of watermelons. *Annual Report (1933) of Texas Agricultural Experiment Station* No. 46, 88.

5 WIANT J.S. (1937) Investigations of the market diseases of cantaloups and Honey Dew and Honey Ball melons. *Technical Bulletin of the United States Department of Agriculture* No. 573, 47 pp illus.

CHARCOAL ROT of melons, watermelons, marrows, squashes and pumpkins caused by
Macrophomina phaseolina **(Tassi) Goid.**

16



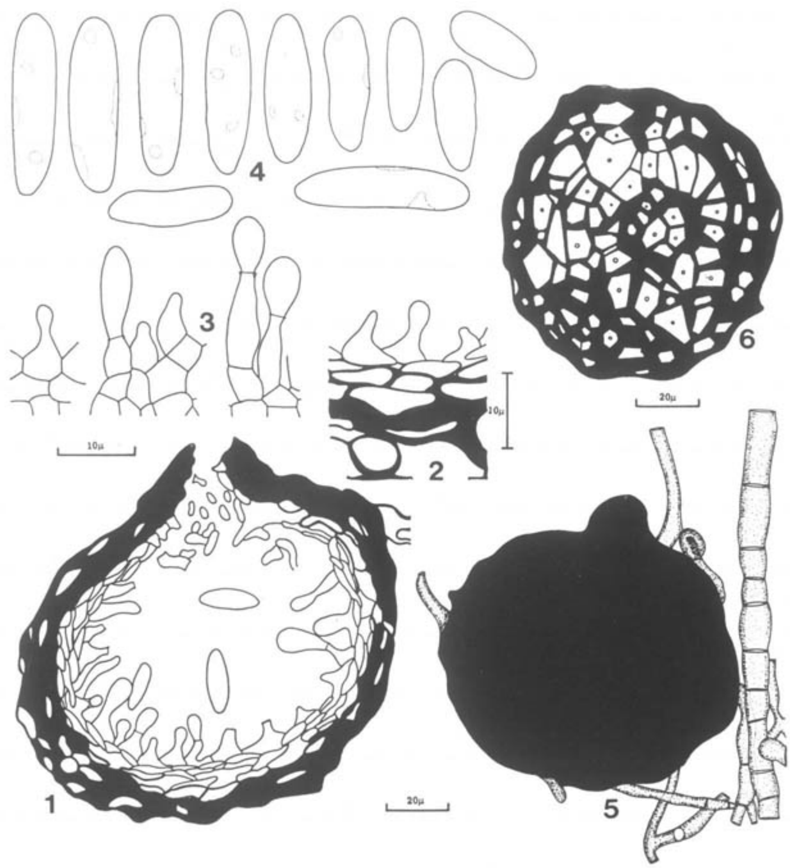
17

OCCURRENCE The fungus is widespread in the tropics and subtropics, and can cause epidemics during hot dry seasons (10). Charcoal rot is of particular importance on melons, and has been found on rotted fruits in India (9), Israel (3,7), the southern USA and Chile (2). It has also been recorded on watermelons and marrows in India (9) and on watermelons, squashes and pumpkins in the southern USA (10).

SYMPTOMS A watersoaked spot appears on the skin and, under favourable conditions, enlarges rapidly, the affected area being firm in texture with an indefinite boundary. A bright purple or pink coloration may be associated with the lesion, both externally and internally (2) (cf. fusarium rot, q.v.). As the decay advances, the skin becomes wrinkled and there is profuse development of very minute spherical black bodies (microsclerotia). They are so small as to appear almost powdery, hence the name 'charcoal rot'. This superficial crust tends to rupture, exposing watery flesh which emits a pungent odour and eventually turns black. Sometimes infected fruits become hollow shells, of which the interior is also blackened (10).

BIOLOGY Under dry conditions the small resting bodies (microsclerotia) persist in the soil (1,5,8) or in the roots of plants (4). Infection of growing crops is most severe during hot weather (7), the optimal growth temperature for the fungus being 30° to 35°C. Roots are invaded (3) and the fungus then progresses into the stems (2). Fruits may become infected before harvest, either via the stem-end or from the soil through a wound in the skin of fruit in contact with the ground (9). Infection of fruits may also occur at the time of harvest. Occasionally the fungus produces the asexual state (pycnidia giving rise to conidia) on stems (2) or on fruits (9). Seeds are often infected, thereby transmitting disease to the next crop (3,6,7).

CONTROL Soil can be disinfected by drenching with a fungicide; however, it is not easy to kill this fungus (5). Clean or treated seed should be planted (7). Control has been achieved by coating seeds with a preparation containing an organism which is antagonistic to the fungus but otherwise harmless (biological control) (3). If rain is infrequent, irrigation should be carried out regularly (10), firstly so that the plants are not weakened by drought stress (3) and secondly because the charcoal rot fungus survives poorly in wet soil (1,8). Fruits can be protected by means of a post-harvest fungicide dip and by the use of refrigerated storage.



18 *Macrophomina phaseolina* (from CMI Descr. No. 275, Holliday & Punithalingam 1970) 1 pycnidium 2 part of pycnidial wall and conidiophores 3 conidiophores and young conidia 4 conidia 5 sclerotium 6 section of sclerotium

1 BANERJEE S., MUKHERJEE B. & SEN C. (1983) Survival of mycelia and sclerotia of *Macrophomina phaseolina* in soil: influence of moisture and temperature. *Indian Journal of Plant Pathology* **1**, 20–23.

2 CARTER W.W. (1979) Importance of *Macrophomina phaseolina* in vine decline and fruit rot of cantaloup in south Texas. *Plant Disease Reporter* **63**, 927–930 illus.

3 ELAD Y., ZVIELI Y. & CHET I. (1986) Biological control of *Macrophomina phaseolina* (Tassi) Goid. by *Trichoderma harzianum*. *Crop Protection* **5**, 288–292.

4 GHAFFAR A. & AKHTAR P. (1968) Survival of *Macrophomina phaseolina* (Maubl.) Ashby in cucurbit roots. *Mycopathologia et Mycologia Applicata* **35**, 245–248.

5 HARTZ T.K., CARTER W.W. & BRUTON B.D. (1987) Failure of fumigation and solarization to control *Macrophomina phaseolina* and subsequent muskmelon vine decline. *Crop Protection* **6**, 261–264.

6 MAHOLAY M.N. & SOHI H.S. (1983) *Macrophomina* seed rot of bottlegourd, squash and muskmelon. *Indian Journal of Mycology and Plant Pathology* **13**, 192–197.

7 REUVENI R., NACHMIAS A. & KRIKUN J. (1983) The role of seedborne inoculum on the development of *Macrophomina phaseolina* on melon. *Plant Disease* **67**, 280–281.

8 SHOKES F.M., LYDA S.D. & JORDAN W.R. (1977) Effect of water potential on the growth and survival of *Macrophomina phaseolina*. *Phytopathology* **67**, 239–241.

9 SINGH R.S. & COLHOUN J.S. (1972) Studies on charcoal rot of cucurbits. *Plant Disease Reporter* **56**, 115–118 illus.

10 YOUNG P.A. (1949) Charcoal rot of plants in east Texas. *Bulletin of Texas Agricultural Experiment Station* No. 712, 33 pp illus.

CHOANEPHORA ROT of cucumbers, watermelons, marrows, squashes and pumpkins caused by

***Choanephora cucurbitarum* (Berk. & Rav.) Thaxt.**

19

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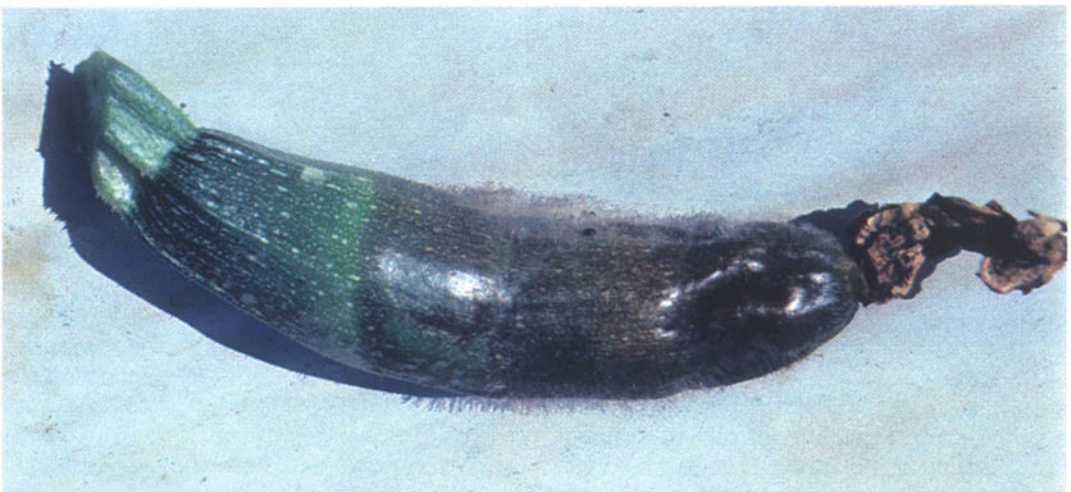
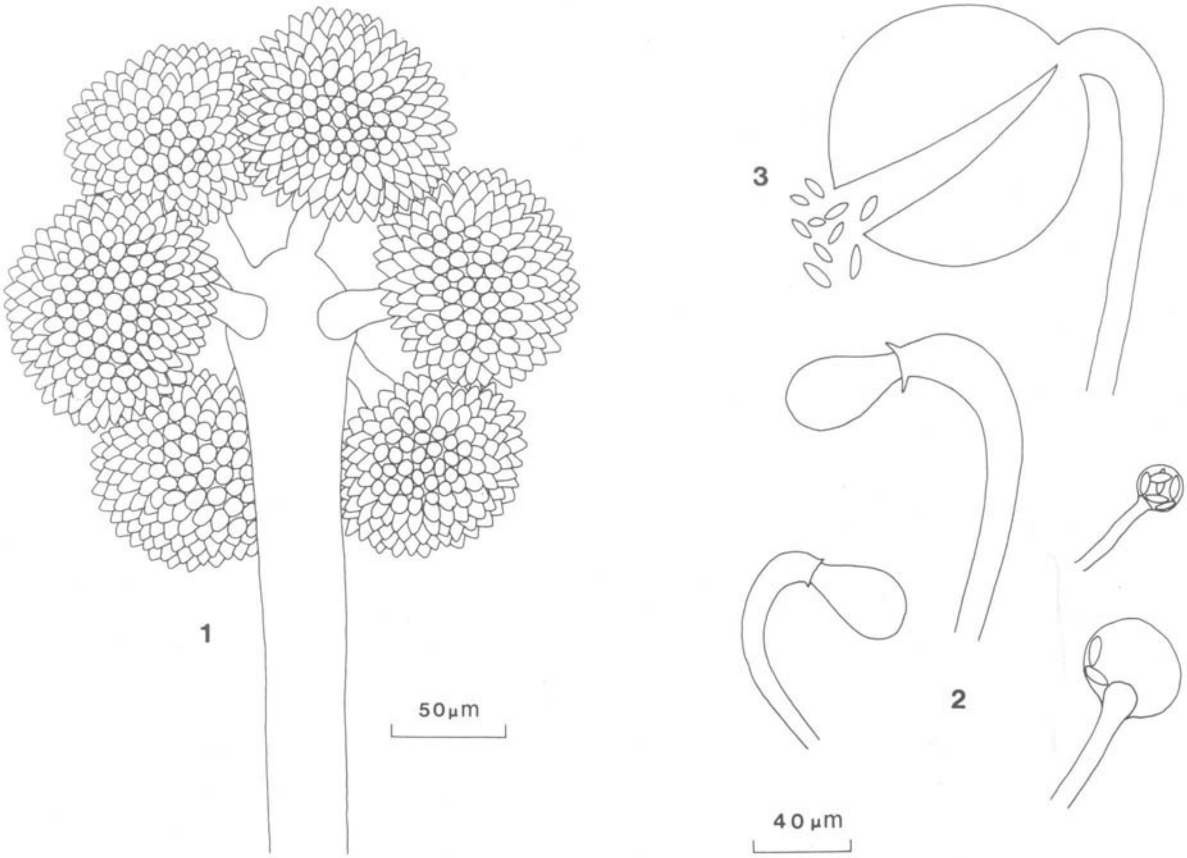


OCCURRENCE This fungus has caused severe losses of marrows in Egypt (1,3) and Romania (8), squashes in the USA (10) and pumpkins in the USA (2) and India (7). It is less important on cucumbers (9) and watermelons (6). A closely related fungus (*Cunninghamella echinulata* (Thaxt.) Thaxt. ex Blakeslee) has been found on pumpkins in India (4).

SYMPTOMS A soft wet rot develops, usually starting at the blossom-end of the fruit (1,8). Under humid conditions there is a luxuriant growth of whitish mould, which takes on a characteristic metallic lustre (10). Numerous spore-heads develop (giving rise to sporangiospores) and turn from white to brown to purplish-black. Decay is very rapid at temperatures between 25° and 30°C. In a cooler, drier environment there may be no development of mould on the surface, and the fruits merely turn brown (8).

BIOLOGY As well as producing two types of asexual spores (sporangiospores and conidia) the fungus can also exist in the sexual state (zygospores) or as resting spores (chlamydospores) in the soil (2,6,8,10). Sporangiospores are disseminated by wind and insects and, under warm wet growing conditions, dying flowers become infected (10). From the female flowers the fungus subsequently invades the fruit, and decay may occur in the field or during marketing (1,8).

CONTROL Crop rotation is beneficial, provided that the cucurbit crop does not follow other susceptible crops such as legumes, peppers, cauliflowers, okra or cotton (8). Since disease development is favoured by excessive moisture, care should be taken to ensure good drainage, moderate irrigation, a low crop density and freedom from bushy weeds (8). If wet conditions are unavoidable, a fungicide spray can



21 *Choanephora cucurbitarum* (from *Mycological Papers* No. 152, Kirk 1984) 1 mature sporangioliferous sporangiophore bearing six fertile vesicles 2 sporangial fructifications 3 sporangiospores

be used (3). If infection is noticed in the growing crop, all affected fruits should be removed and destroyed, and the plants burned after harvest (8).

The use of refrigerated storage serves to minimise decay in fruits harvested in apparently sound condition.

1 ABD-EL-REHIM M.A., ELAROSI H. & MICHAIL S.H. (1964) Choanephora fruit rot of vegetable marrow in the U.A.R. (Egypt). *Alexandria Journal of Agricultural Research* **12**(2), 123–128 illus.
2 BARNETT H.L. & LILLY V.G. (1956) Factors affecting the production of zygospores by *Choanephora cucurbitarum*. *Mycologia* **48**, 617–627.
3 EL-HELALY A.F., ASSAWAH M.W., ELAROSI H.M. & WASFY E.-E.H. (1968) Studies on the control of *Choanephora* blossom end rot and powdery mildew of vegetable marrow in Egypt (U.A.R.). *Phytopathologia Mediterranea* **7**, 145–149.
4 GROVER R.K. (1965) A pathogenic *Cunninghamella* on pumpkin and its control. *Indian Phytopathology* **18**, 257–266.
5 HIGHAM M.T. & COLE K.M. (1982) Fine structure of sporangiole development in *Choanephora cucurbitarum* (Mucorales). *Canadian Journal of Botany* **60**, 2313–1324 illus.
6 KIRK P.M. (1984) A monograph of the *Choanephoraceae*. *Mycological Papers* No. 152, 61 pp illus.
7 MUSTAFEE T.P. (1972) Premature fruit-rot of pumpkin caused by *Choanephora cucurbitarum* in Assam. *Science and Culture* **38**, 142–143.
8 PUŞCAŞU A. (1984) [Marrow wet rot and its control.] *Producţia Vegetală, Horticultura* **33**(7), 6–8 illus.
9 SUMNER D.R. & SMITTLE D.A. (1976) Etiology and control of fruit rot of cucumber in single harvesting for pickles. *Plant Disease Reporter* **60**, 304–307.
10 WOLF F.A. (1917) A squash disease caused by *Choanephora cucurbitarum*. *Journal of Agricultural Research* **8**, 319–327 illus.

CLADOSPORIUM ROT, GUMMOSIS and SCAB of cucumbers, melons, watermelons, marrows, squashes and pumpkins caused by ***Cladosporium* spp.**

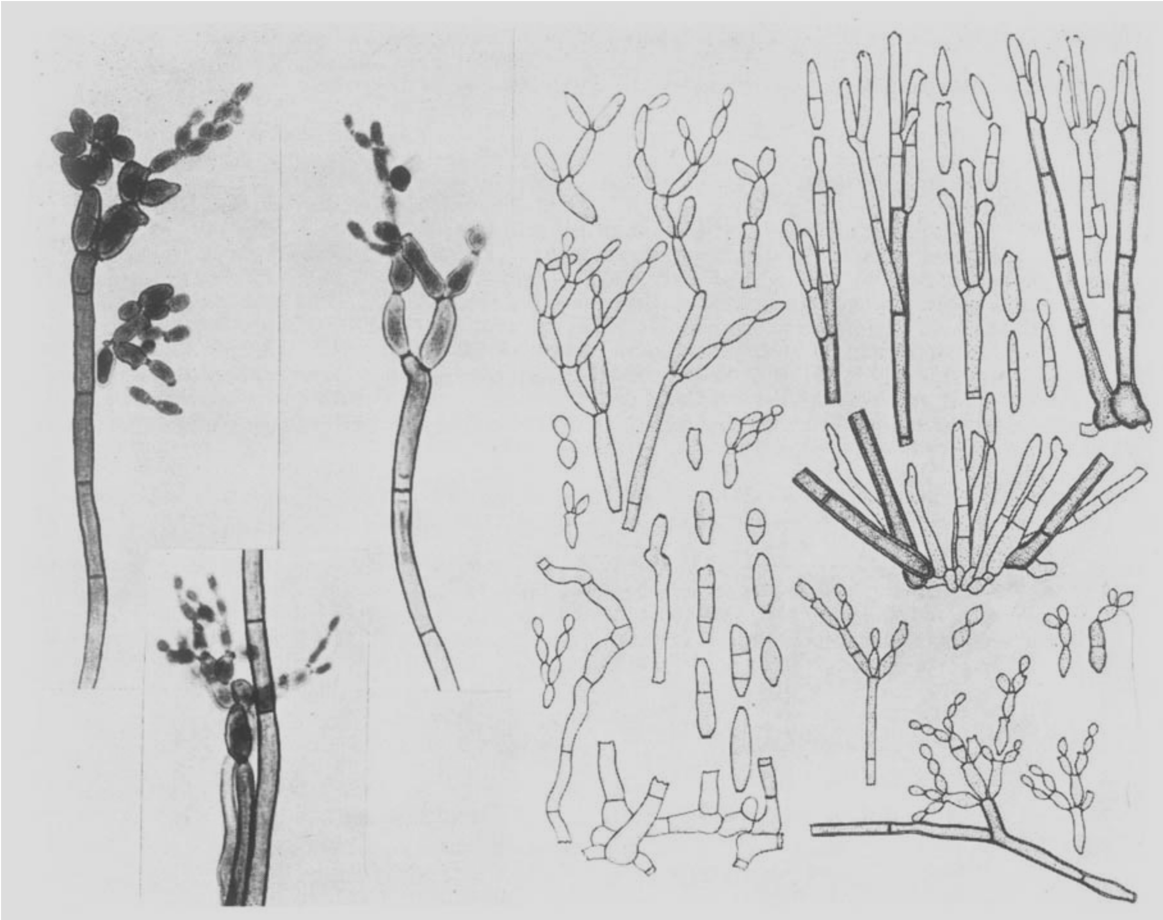
22

OCCURRENCE *Cladosporium cucumerinum* Ell. & Arth. causes losses mainly in temperate countries (7,8). It has been recorded on cucumbers in the northern USA (8), Canada, the Netherlands (6), Czechoslovakia (7) and the USSR (3). In Germany the disease was found to be more prevalent on outdoor cucumbers than on the greenhouse crop (2), while the reverse was found in the USA. The same fungus has also been recorded on melons and squashes in the USA (8) and on marrows in Italy (5). *C. cucumerinum* has not been recorded in Australasia but related species, *C. cladosporioides* (page 64) and *C. herbarum*, cause blemishes on Australian melons (9). *C. tenuissimum* has been recorded on watermelon fruits in India (1), and an unidentified species of *Cladosporium* has been found on Portuguese melons (4).

SYMPTOMS On immature fruits, such as young marrows, lesions caused by *C. cucumerinum* are circular (up to 1 cm in diameter), watersoaked and deeply sunken. They tend to exude a gummy substance which dries and darkens (2). Subsequently, under humid conditions, a velvety silver-grey mould develops, turning to olive-green with the formation of a dense mat of spores (conidia). On mature fruits lesions are essentially superficial and take the form of brown corky scabs. On melons symptoms vary with cultivar (10). Netted melons tend to be particularly vulnerable at the stem-scar, which may become thickly covered with dark mould; sparse mould growth may also develop between the netted areas on the fruit surface. In Honey Dews the characteristic symptom is discrete dark circular spots, each of which may be surrounded by a pale brown halo. In a humid atmosphere the smooth surface of the lesions becomes covered with olive-black mould (10). Other species of *Cladosporium* on melons may cause superficial blemishes (9), a shallow stem-end decay or severe rotting (4).

BIOLOGY These fungi survive in plant debris in the soil, and during wet or humid weather (1) they produce abundant spores (conidia) which are probably disseminated in air currents. A severe leaf blight can occur (1). *C. cucumerinum* thrives in the moist environment produced by fog or dew (7), and optimal conditions for disease development are air temperatures fluctuating around 20°C together with persistent high humidity (3,8). In cucumber crops the fungus is capable of direct penetration of young fruits, but can invade older fruits only through wounds (2,6). Incipient infections continue to develop after harvest, even under refrigeration. In one of the earliest studies of chilling injury (q.v.) in stored melons, it was noticed that cladosporium rot was often associated (10); fruit stored at too low a temperature is predisposed to general invasion by this fungus. The other species of *Cladosporium* have similar characteristics but are able to survive higher temperatures in the field.

CONTROL In cucumber an effective means of control has been the development of resistant cultivars (7). For melons, marrows, squashes and pumpkins, it may be advisable to sterilise the soil before planting, and to spray the crop with a systemic fungicide early in the growing season (5). Greenhouses should be well ventilated in order to prevent a build-up of moisture (3,6). Post-harvest rotting can be controlled by dipping the fruit in a fungicide (9), holding at the correct temperature, and avoiding prolonged storage.



23 *Cladosporium cucumerinum* (from CMI Descr. No. 348, Ellis & Holliday 1972) Conidia and conidiophores × 500

1 AVDHESH NARAIN, SWAIN N.C., SAHOO K.C., DASH S.K. & SHUKLA V.D. (1985) A new leaf blight and fruit rot of watermelon. *Indian Phytopathology* **38**, 149–151.

2 BEHR L. (1948) Histologische Untersuchungen an krätzekranken Gurken (*Cucumis sativus* L.) unter besonderer Berücksichtigung des Krankheitsverlaufes der Krätze (*Cladosporium cucumerinum* Ell. et Arth.) an Früchten. *Phytopathologische Zeitschrift* **15**, 92–123.

3 DOROZHKIN N.A., REMNEVA Z.I. & NALOBOVA V.L. (1976) [Effects of temperature and relative humidity on the development of *Cladosporium cucumerinum* Ell. & Arth., the pathogen of green mould rot of cucumber.] *Mikologiya i Fitopatologiya* **10**, 497–503.

4 ESTEVES É. (1961) Uma doença do melão. *Agricultura (Revista da Direcção-Geral dos Serviços Agrícolas) Lisboa* **11**, 20–21 illus.

5 FRANCESCHINI A., CARTA C. & FIORI M. (1983) Prove di lotta contro il *Cladosporium cucumerinum* Ell. et Arth. agente della cladosporiosi dello zucchino. *Studi Sassaresi III* **30**, 3–9.

6 HERINGA-WESTERHOF A.C. (1946) Het Vruchtvuur in der Konkommers veroorzaakt door *Cladosporium cucumerinum* Ellis et Arthur en zijn bestrijding. *Tijdschrift over Plantenziekten* **52**, 138–139.

7 LEBEDA A. (1985) Resistance of *Cucumis sativus* cultivars to *Cladosporium cucumerinum*. *Scientia Horticulturae* **26**, 9–15.

8 STRIDER D.L. & WINSTEAD N.N. (1960) Effect of temperature, pH, and various nutrients on growth of *Cladosporium cucumerinum*. *Phytopathology* **50**, 583–587.

9 WADE N.L. & MORRIS S.C. (1982) Causes and control of cantaloupe postharvest wastage in Australia. *Plant Disease* **66**, 549–552.

10 WIANT J.S. (1938) Market-storage studies of Honey Dew melons and cantaloups. *Technical Bulletin of the United States Department of Agriculture* No. 613, 18 pp illus.

COTTONY LEAK and **PYTHIUM ROT** of cucumbers, melons, watermelons, marrows, squashes, pumpkins and chayotes caused by ***Pythium* spp.**

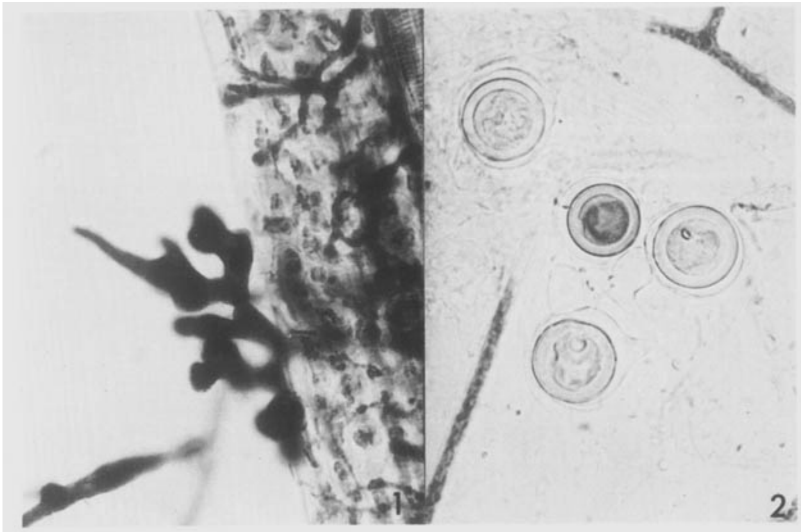
24

OCCURRENCE This important disease has been recorded in many countries, both temperate and tropical. Some examples are *P. aphanidermatum* (Edson) Fitzp. on cucumbers in the USA (3,9), on cucumbers and squashes in Iraq (8), on melons in India (4) and on pumpkins in the USSR (5); *P. butleri* Subram. on cucumbers in Egypt and on melons and watermelons in India (7); *P. debaryanum* Hesse on chayotes in Italy (1); *P. myriotylum* Drechsler on watermelons in the USA (2); *P. ultimum* Trow on watermelons and pumpkins in the USA (10). Several other species of *Pythium* have been found on cucurbits (2).

SYMPTOMS Soft dark lesions develop on the fruit, often at the blossom-end or at the stem-end (10). Infected flesh undergoes a rapid breakdown, releasing copious quantities of liquid (1,10), and there may be a slight 'marshy' odour. There is usually a luxuriant growth of bright white mould, loose and fluffy (1) or densely woven (10), according to species. Numerous thick-walled spherical spores (oospores) develop in the rotted flesh. In watermelons the mould is usually confined to the internal tissues, the characteristic symptom being a dark brown lesion at the blossom-end (2).

BIOLOGY These fungi are common soil inhabitants and thrive in wet conditions. They produce both the sexual stage (oospores) and the asexual stage (sporangia which may give rise to zoospores). During rain or irrigation spores are splashed on to low-hanging fruits and, except in watermelons, can cause direct infection in the absence of wounds (10). Fruits in contact with the ground are especially vulnerable (4). Infection also occurs via the flower parts or, at harvest time, via the cut stem. The optimal growth temperatures for these fungi are in the range 28° to 37°C (3), but they can also cause severe infection

25



26 *Pythium aphanidermatum* (from CMI Descr. No. 36, Waterhouse & Waterston 1964) 1 sporangia × 330 2 oospores × 500 (stained with cotton blue in lactophenol)

under cool conditions (7,10). Decay spreads rapidly during transit and storage, with the formation of 'nests' of mouldy fruits exuding watery juices (1,3).

CONTROL Seed treatment is sometimes recommended, and it is advisable to practise crop rotation, excluding other susceptible crops such as tomatoes, peppers and eggplants (5). Fields should be well drained and carefully irrigated. In greenhouses a layer of plastic film on the ground serves to prevent contact between soil and fruits (4); alternatively a fungicide may be applied to the growing crop (5). Studies have been made on the use of a post-harvest dip containing antagonistic soil fungi which delay the development of pythium rot (6). During hot humid weather prompt pre-cooling of produce is essential before long distance refrigerated shipment (3).

1 DRECHSLER C. (1925) The cottony leak of cucumbers caused by *Pythium aphanidermatum*. *Journal of Agricultural Research* **30**, 1035–1042 illus.

2 DRECHSLER C. (1939) Several species of *Pythium* causing blossom-end rot of watermelons. *Phytopathology* **29**, 391–422.

3 McCOMBS C.L. & WINSTEAD N.N. (1963) Control of cucumber cottony leak in transit. *Proceedings of the American Society for Horticultural Science* **83**, 538–546.

4 PILLAI S.N., PATEL J.R. & PATEL A.J. (1979) Control of fruit rot in watermelon. *Phytoparasitica* **7**, 17–22.

5 ROMANOVICH E.A. (1958) [New disease of pumpkins.] *Zashchita Rastenii, Moscow* **6**, 53–54.

6 SHARMA B.B., WAHAB S. & NEERAJ (1981) Studies on certain antifungal soil-fungi as control agents against cottony leak in cucurbit fruits. *Indian Phytopathology* **34**, 250–252.

7 SINGH R.S. & CHOHAN J.S. (1977) Factor affecting growth and fruit rot (cottony leak) of cucurbits caused by *Pythium butleri*. *Indian Phytopathology* **30**, 379–383.

8 TARABEIH A.M., AL-ZARARY A.J., MICHAIL S.H. & SHAWKAT A.L.B. (1979) Damping-off and fruit-rot of certain cucurbitaceous plants in Iraq. *Acta Phytopathologica Academiae Scientiarum Hungaricae* **14**, 23–30.

9 THOMPSON D.C. & JENKINS S.F. (1985) Control of cottony leak of cucumber with different formulations of metalaxyl applied at various rates and times. *Phytopathology* **75**, 1362 [Abstract].

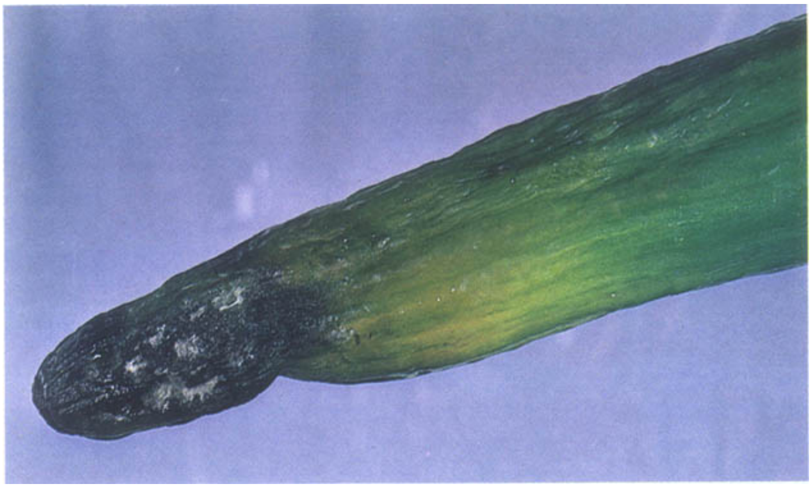
10 TOMPKINS C.M., ARK P.A., TUCKER C.M. & MIDDLETON J.T. (1939) Soft rot of pumpkin and watermelon fruits caused by *Pythium ultimum*. *Journal of Agricultural Research* **58**, 461–475 illus.

DIDYMELLA BLACK ROT of cucumbers, melons, watermelons, marrows, squashes, pumpkins and chayotes caused by

Didymella bryoniae **(Auersw.) Rehm**

Conidial state: *Phoma cucurbitacearum* (Fr.) Sacc.

27

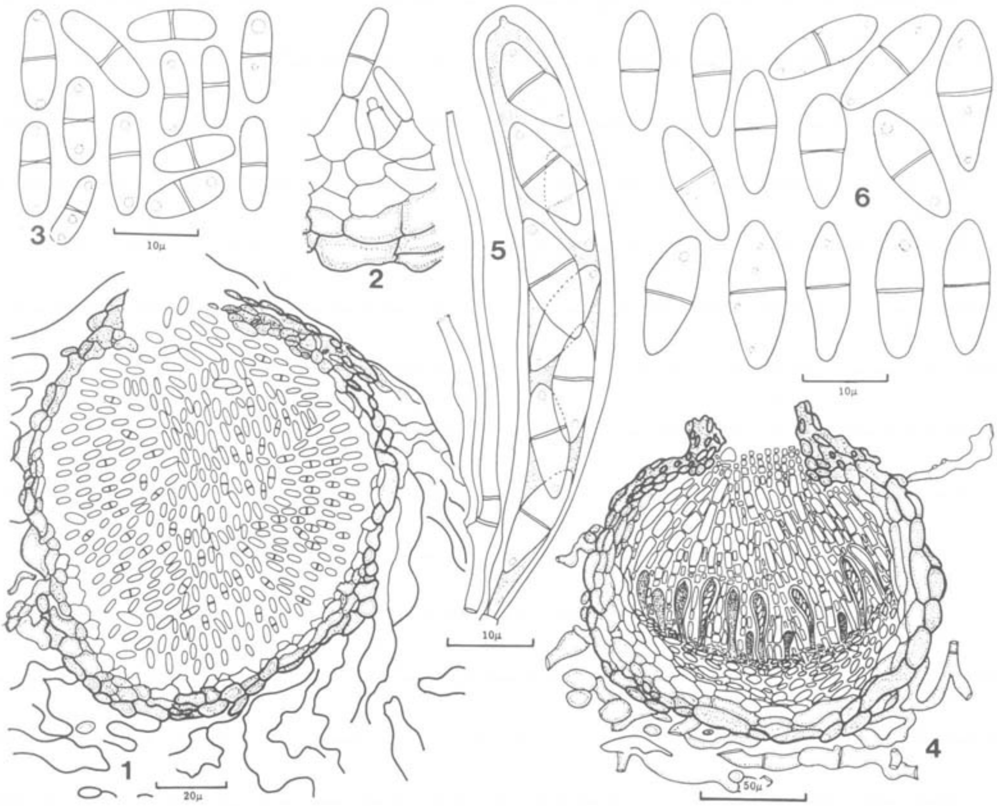


OCCURRENCE Black rot of cucurbit fruits is important both in subtropical and in cool temperate regions. For example, the disease occurs on cucumbers in the Netherlands (9) and the UK (5); on melons in Chile (7); on watermelons in the southern USA (8); on marrows in Brazil (2); on squashes in Cuba and the USA (10); on pumpkins in Trinidad (1) and Denmark (6); and on chayotes from India, Jamaica and Puerto Rico (10).

SYMPTOMS Lesions on the fruit surface are at first watersoaked and roughly circular, sometimes zonate, later becoming dark, sunken and cracked. A gummy exudate is often produced (although this is not usual in watermelons) (8) and, under humid conditions, a whitish mould may develop (10). The most characteristic symptom, however, is the production of two types of minute black bodies on the surface of the lesion, together with a gradual shrivelling and wrinkling of affected tissue. 'Internal fruit rot' (9) is characterised by a constriction of the flower end and no other obvious symptoms except a blackening of the extreme tip (10). Infected flesh is brown, soft and odourless.

BIOLOGY The fungus remains dormant in dry crop debris, and resumes activity at the onset of rain or irrigation (3). It exists, often simultaneously, in both the sexual state (perithecia giving rise to ascospores) and the asexual state (pycnidia giving rise to conidia) (7,8). The two types of spores are disseminated by wind and water respectively, and can give rise to the field disease known as gummy stem blight (1). Fruits may be invaded via the dying flowers, or through the cut stem at harvest time (2,5,9). Alternatively the fungus gains entry through injuries in the skin caused by insects during the growing season and by rough handling at harvest (8). At temperatures between 20° and 25°C rotting is rapid (3); mould strands permeate the flesh and infect the seeds, which may thereby transmit the disease to the next crop (6,7).

CONTROL Debris from any previous infected crop should be promptly removed and destroyed (7). Clean or treated seed should be used, and in high value protected crops it may be advisable to carry out soil sterilisation before planting. Insects should be controlled during the growing season, and fungicide sprays applied (4). Irrigation should be frequent so as to prevent drought stress (9). Where flower infection is common it has been recommended that dead flowers be removed by hand during periods when temperature and humidity are conducive to infection (2). Beneficial reduction of humidity in greenhouses can be achieved by judicious ventilation (5) and the use of supplementary heating early in the mornings. Care is needed at harvest time, firstly to ensure that the fungus is not transmitted to the cut stem by contaminated knives (5) and secondly to prevent unnecessary injury to the skin of the fruit (8). If infection has occurred, decay can be partially controlled by prompt cooling and storage at the optimal temperature for the cultivar concerned (4). A few cultivars of cucumber, melon and watermelon are resistant, some by virtue of their flowering characteristics (9).



28 *Didymella bryoniae* (from CMI Descr. No. 332, Punithalingam & Holliday 1972) 1 pycnidium 2 part of pycnidial wall and conidiophores 3 conidia 4 pseudothecium 5 ascus and pseudoparaphysis 6 ascospores

1 BALA G. & HOSEIN F. (1986) Studies on gummy stem blight disease of cucurbits in Trinidad. *Tropical Agriculture* **63**, 195–197.

2 CARDOSO R.M.G., FIGUEIREDO M.B., PALAZZO D. & MARTINEZ J.A. (1974) Epidemiology of fruit rot (*Mycosphaerella melonis* (Pass.) Chiu & J.C. Walker) on Italian squash (*Cucurbita pepo* L.). *Arquivos do Instituto Biológico* **41**, 35–37.

3 CHIU W.F. & WALKER J.C. (1949) Physiology and pathogenicity of the cucurbit black rot fungus. *Journal of Agricultural Research* **78**, 589–615.

4 DOW A.T., SEGALL R.H., HOPKINS D.L. & ELSTROM G.W. (1978) Effects of storage temperature and field fungicide treatments on decay of Florida watermelons. *Proceedings of Florida State Horticultural Society* **91**, 149–150.

5 FLETCHER J.T. & PREECE T.F. (1967) Mycosphaerella stem rot of cucumbers in the Lea Valley. *Annals of Applied Biology* **58**, 423–430.

6 LEE D.-H., MATHUR S.B. & NEERGAARD P. (1984) Detection and location of seed-borne inoculum of *Didymella bryoniae* and its transmission in seedlings of cucumber and pumpkin. *Phytopathologische Zeitschrift* **109**, 301–308.

7 SANZ B.-M., H. (1971) *Mycosphaerella melonis* (Pass.) Chiu and Walker, una nueva enfermedad de las cucurbitáceas en el país. *Agricultura Técnica* **31**, 142–144.

8 SCHENCK N.C. (1962) Mycosphaerella fruit rot of watermelon. *Phytopathology* **52**, 635–638 illus.

9 STEEKELENBURG N.A.M. van (1986) Factors influencing internal fruit rot of cucumber caused by *Didymella bryoniae*. *Netherlands Journal of Plant Pathology* **92**, 81–91 illus.

10 WIANT J.S. (1945) Mycosphaerella black rot of cucurbits. *Journal of Agricultural Research* **71**, 193–213 illus.

FUSARIUM ROT of cucumbers, melons, watermelons, marrows, squashes, pumpkins and chayotes caused by

***Fusarium* spp.**

29

OCCURRENCE Several species of *Fusarium* have been found on cucurbit fruits. Examples are *F. equiseti* (Corda) Sacc. on melon in Turkey (3) and on watermelon in India (8); *F. oxysporum* on cucumber and watermelon in the USA (4,6); *F. pallidoroseum* (Cooke) Sacc. on melon and squash in France (9), and on melon in India (10), central America and the USA (1); and *F. solani* (Mart.) Sacc. on cucumber and melon in Israel (5), on watermelon in Nigeria (2) and on squash in the Netherlands (7). Fusarium rot of chayotes has been reported from India.

SYMPTOMS Lesions may occur anywhere on the fruit but are frequently found at the stem-end (9). Affected tissue tends to be spongy or corky and, under humid conditions, becomes covered with a white or pinkish mould. Decay may be shallow or extend to the seed cavity, and there is usually a distinct line of demarcation between healthy and rotted tissue (1,9). A reddish-purple pigment is sometimes produced (cf. charcoal rot, q.v.).

BIOLOGY These fungi are common in soil, and survive as thick-walled resting spores (chlamydospores). These germinate to produce mould strands which can invade plant roots and cause wilting, followed by stem-rot and fruit-rot (4). Thin-walled asexual spores (conidia) are also produced, and these are disseminated by wind and water. A wound is necessary for infection through the skin of the fruit (3), and may be in the form of insect damage (2) or abrasion; disease incidence is especially high in thin-skinned cultivars (10). Further infections, resulting in a stem-end rot, can be caused during harvesting if knives become contaminated through contact with soil or with infected plant tissue. The optimal growth temperatures for these fungi lie between 22° and 29°C. If decay progresses to the seed cavity, the seeds become infected and may transmit the disease to the next crop.

30

31 *Fusarium equiseti* (from CMI Descr. No. 571, Booth 1978) Conidia and conidiophores × 750 (stained with cotton blue in lactophenol)

CONTROL It may be necessary to disinfect the soil (7), to use a seed dressing, and to protect the developing crop from insect pests (2). A systemic fungicide can be sprayed on to the growing crop, and its protective action continues after harvest (9). Careful inspection in the packhouse (1) helps to eliminate most fruits with slight pre-harvest infections, and gentle handling serves to minimise the incidence of wound infections (3). Post-harvest treatments alone are not always effective (9), although improved control can be achieved by heating the fungicide dip. Subsequently fruit should be held under refrigeration, since at 10°C these fungi develop slowly.

1 CARTER W.W. (1979) Corky dry rot of cantaloup caused by *Fusarium roseum* 'semitectum'. *Plant Disease Reporter* **63**, 1080–1084 illus.
2 IKEDIUGWU F.E.O. & OGIEVA W.O. (1978) Fruit rot of *Citrullus lanatus* in Nigeria caused by *Fusarium solani*. *Transactions of the British Mycological Society* **71**, 209–213.
3 IREN S. & SORAN H. (1973) Untersuchungen über die Feststellung und pathogenität des Zuckersmelonen-fruchtfäuleerregers *Fusarium equiseti* (Corda) Sacc. *Journal of Turkish Phytopathology* **2**, 130–139.
4 JENKINS S.F. & WEHNER T.C. (1983) Occurrence of *Fusarium oxysporum* f.sp. *cucumerinum* on greenhouse-grown *Cucumis sativus* seed stocks in North Carolina. *Plant Disease* **67**, 1024–1025.
5 JOFFE A.Z. & PALTI J. (1972) *Fusarium* species of the *Martiella* section in Israel. *Phytopathologische Zeitschrift* **73**, 123–148.
6 McMILLAN R.T. (1986) Cross pathogenicity studies with isolates of *Fusarium oxysporum* from either cucumber or watermelon pathogenic to both crop species. *Annals of Applied Biology* **109**, 101–105.
7 PATERNOTTE S.J. (1987) Pathogenicity of *Fusarium solani* f.sp. *cucurbitae* race 1 to courgette. *Netherlands Journal of Plant Pathology* **93**, 245–252.
8 SUMBALI G. & MEHROTRA R.S. (1982) Cucurbitaceous fruits – new hosts for *Fusarium equiseti*. *National Academy of Science Letters* **5**, 121–122.
9 TROUILLON P. & TISSUT M. (1972) Contribution à l'étude d'une fusariose de fruits de cucurbitacées et de ses possibilités de traitement. *Phytiatrie-Phytopharmacie* **21**, 61–67.
10 WARAITCH K.S. & NANDPURI K.S. (1975) Fusarium fruit rot of muskmelon (*Cucumis melo* L.). *Journal of Research of Punjab Agricultural University* **12**, 131–134.

GREY MOULD ROT of cucumbers, melons, marrows, squashes and pumpkins caused by

Botryotinia fuckeliana **(de Bary) Whetzel**

Conidial state: *Botrytis cinerea* Pers.

32

OCCURRENCE Grey mould rot is especially important on cucumbers in cool temperate countries, for example Japan (2), the northern USA (3), Canada (4) and the UK. It has caused losses of melons in France (1) and squashes in Israel (5); marrows and pumpkins may also be attacked.

SYMPTOMS The infected area (frequently at the flower end) is soft, watersoaked and yellowish, later becoming covered with abundant grey mould, spores (conidia) and occasionally irregular shaped black resting bodies (sclerotia) approximately 2 to 3 mm across.

BIOLOGY The fungus survives on plant debris in the soil and, during wet weather or humid greenhouse conditions, it produces abundant asexual spores (conidia) which are disseminated in air currents (2). In the presence of moisture dying blossoms are colonised by the mould, which is subsequently able to invade the fruit (3,4). Infection may also occur via wounds or through the cut stem at harvest time. The optimal growth temperature for the fungus is approximately 20°C, but substantial rotting can also occur at normal cold store temperatures for cucurbits (pages 12–15).

CONTROL Strict hygiene is important; prompt destruction of crop debris helps to reduce the number of spores released into the atmosphere. Spore production can be inhibited in greenhouses made from special plastic film which cuts out certain ultraviolet wavelengths (2); however, inhibition may be short-lived as the fungus adapts. Irrigation and ventilation should be well controlled to prevent the build-up of excessive moisture, and fungicide sprays should be carefully timed (4). Some fungicides remain effective for only one or two seasons, owing to the emergence of new strains of fungus tolerant of the chemical. Control measures are similar to those for *Sclerotinia* species (see watery soft rot) (1). The two diseases often occur in the same crop (3), though one or the other may predominate at different times of year (5). If incipient infections are suspected, fruits can be treated with a fungicide immediately after harvest (5). Refrigeration can retard rotting but does not stop it.

1 ANON. (1979) Lutte contre les pourritures des fruits de cucurbitacées (*Botrytis cinerea–Sclerotinia sclerotiorum*). *Revue Horticole* No. 200, 35.

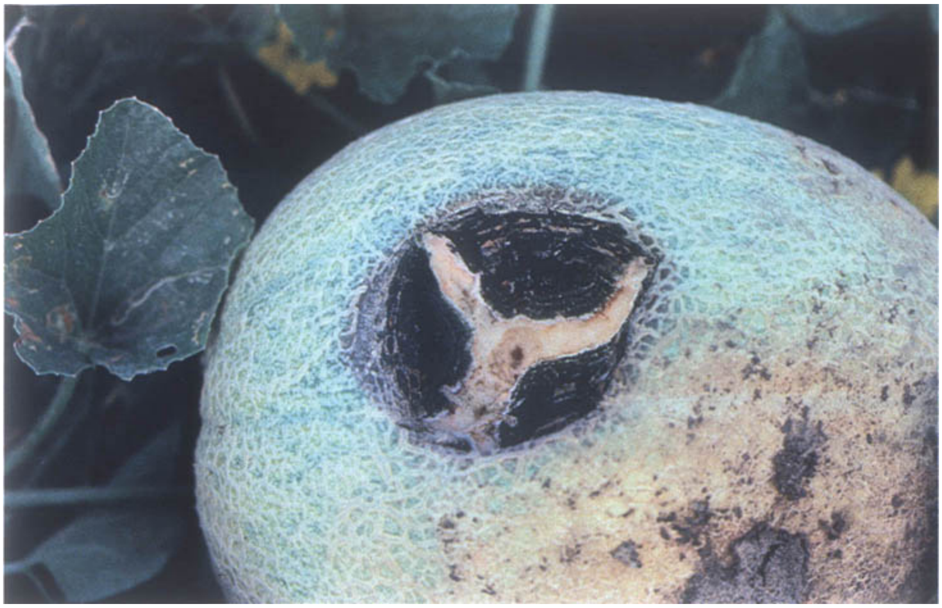
2 HONDA Y. & YUNOKI T. (1980) Inhibition of fungal sporulation by ultraviolet-absorbing vinyl film and its application to disease control. *Japan Agricultural Research Quarterly* **14**, 78–83.

3 KADOW K.J., ANDERSON H.W. & HOPPERSTEAD S.L. (1938) Control of *Sclerotinia* and *Botrytis* stem rots of greenhouse tomatoes and cucumbers. *Phytopathology* **28**, 224–227 illus.

4 McKEEN C.D. (1952) Observations on the occurrence and control of grey mould on greenhouse cucumbers. *Scientific Agriculture* **32**, 670–676.

5 TEMKIN-GORODEISKI N. (1970) Storage rots of zucchini squash (*Cucurbita pepo*) and their control. *Israel Journal of Agricultural Research* **20**, 97–99.

MYROTHECIUM ROT of cucumbers, melons and watermelons caused by ***Myrothecium roridum*** **Tode ex Fr.**



33

OCCURRENCE This fungus has been recorded on cucumbers (5), melons and watermelons in India and on melons from the southern USA and Mexico (1,2,3). A related species, *M. verrucaria* Ditm. ex Fr., is reported on cucumbers in the USSR (4).

SYMPTOMS Lesions on cucumbers are irregular, slightly depressed, and turn from greenish-yellow to dirty red (5); on melons they are dark and sunken. Affected areas support discrete greenish-black spore-masses (sporodochia) which are 1 to 1.5 mm in diameter and fringed with white (3). These bodies may coalesce into a sticky charcoal-black sheath, or become dry, hard and flaky. There is a gradual rotting of the flesh, which becomes watery but does not have a pronounced odour (3). Under humid conditions there is a luxuriant growth of whitish mould, interspersed with spore-masses (5).

BIOLOGY The disease may be seed-borne (4). The fungus is also common in soil, and its spores (conidia) are probably disseminated by wind, water and insects. During warm wet weather infection causes leaf-spotting on many crops; furthermore, flowers may become infected and symptoms are later manifest on fruits in field and packhouse (1). Rotting occurs at temperatures between 10° and 30°C (5). Cultivars differ substantially in their tolerance of this disease (2).

CONTROL Seed treatment may be advisable (4). Field hygiene is important; diseased plant debris should be removed and destroyed before the new crop is planted. A fungicide spray can be effective if applied at the onset of flowering (1). If infected fruit is inadvertently packed, deterioration can be delayed by the use of refrigeration.

1 CARTER W.W. (1980) Incidence and control of *Myrothecium roridum* on cantaloup in relation to time of fungicide application. *Plant Disease* **64**, 872–874.
2 KUTI J.O., NG T.J. & BEAN G.A. (1987) Reactions of muskmelon cultigens to *Myrothecium roridum*. *HortScience* **22**, 635–637.
3 McLEAN D.M. & SLEETH B. (1961) *Myrothecium* rind rot of cantaloup. *Plant Disease Reporter* **45**, 728–729 illus.
4 NIKOLAEVA S.I. & MARZHINA L.A. (1982) [*Myrothecium verrucaria* Ditm. ex Fr., a new pathogen of mycosis of cucumber.] *Mikologiya i Fitopatologiya* **16**, 358–359.
5 RAO V.G. & SUBRAMONIAM V. (1974) Studies into *Myrothecium* rot of cucumber. *Rivista di Patologia Vegetale, Padova IV* **10**, 411–426.

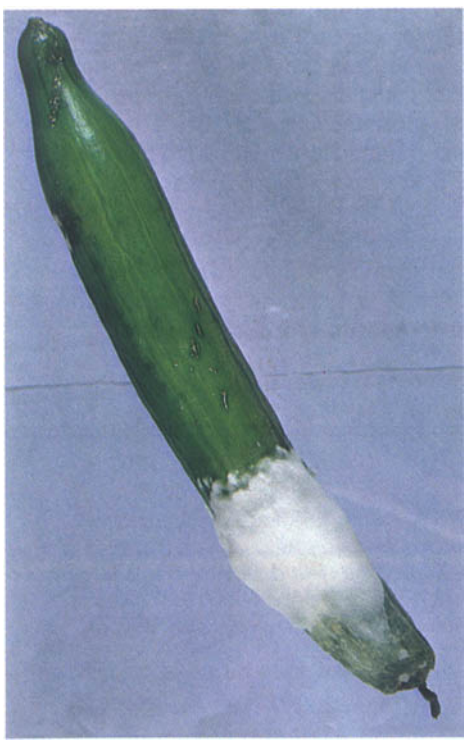
PHYTOPHTHORA ROT of cucumbers, melons, watermelons, marrows, squashes, pumpkins and chayotes caused by
***Phytophthora* spp.**

34

OCCURRENCE Several species of *Phytophthora* cause rotting in cucurbit fruits. Examples are *P. cactorum* (Leb. & Cohn) Schroet. on watermelons in the USA (2); *P. capsici* Leonian on melons in the USA (8), on squashes in Italy (6) and in Argentina (7) and on pumpkins in Japan (4); *P. drechsleri* Tucker on cucumbers and melons in China and on marrows in Egypt (3); and *P. nicotianae* var. *parasitica* on watermelons in the USA (5) and in India (9) and on chayotes in Mauritius (1). Phytophthora rot has also been recorded on Chilean melons imported into the USA (10).

SYMPTOMS Lesions may form on any part of the fruit, and are usually brown with an irregular margin, later becoming zoned or mottled. Under humid conditions a whitish mould develops, on which are produced characteristic spore-heads (sporangia). The skin may rupture, and eventually the entire fruit decays. Infected flesh is soft, watersoaked, rarely discoloured, and almost odourless unless invaded by secondary organisms (2,7,8,9,10).

BIOLOGY These fungi are common soil inhabitants, causing disease under warm wet conditions. They produce both the sexual stage (oospores) (4) and the asexual stage (sporangia which may give rise to zoospores), and infection is often from zoospores disseminated by rain or irrigation water (1,5). Fruits on or near the ground are most likely to be invaded and, in the presence of moisture, the fungus can penetrate the unbroken skin (6,8,9). Fruits may be harvested in apparently good condition, and undergo decay during transport and storage; the mould



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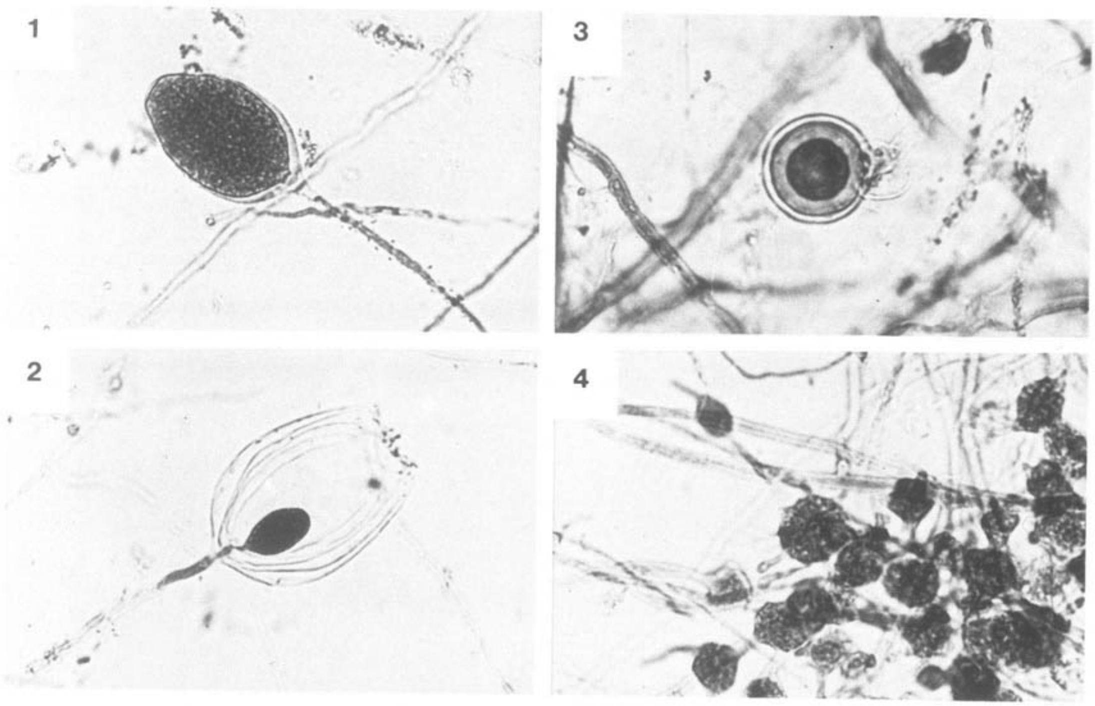

36 *Phytophthora drechsleri* (from CMI Descr. No. 840, Stamps 1985) 1 sporangium 2 sporangium showing internal proliferation 3 oospore 4 hyphal swellings × 500 (stained with cotton blue in lactophenol)

spreads from infected fruits into adjacent sound fruits (10). The optimal growth temperatures for these species of *Phytophthora* lie between 25° and 30°C, and rotting is slow at 10°C and below (3,6,8,10).

CONTROL Fields should be well drained, and properly irrigated so that water does not accumulate (8). A soil fungicide may be applied (6). Decay in harvested fruits can be minimised by the use of refrigeration.

1 ANON. (1963) Plant pathology. *Report of the Department of Agriculture, Mauritius, 1962*, 43–47.
2 BROWN J.G. & EVANS M.M. (1933) A *Phytophthora* rot of watermelon. *Technical Bulletin of Arizona Agricultural Experiment Station* No. 51, 45–65 illus.
3 EL-HELALY A.F., ASSAWAH M.W., ELAROSI H.M. & WASFY E.-E.H. (1968) Fruit rots of vegetable marrow in Egypt (United Arab Republic). *Phytopathologia Mediterranea* 7(2–3), 107–115 illus.
4 KAMJAIPAI W. & UI T. (1978) Mating types of *Phytophthora capsici* Leonian, the causal fungus of pumpkin rot in Hokkaido. *Annals of the Phytopathological Society of Japan* **44**, 440–446.
5 NORTON D.C. & ROSBERG D.W. (1954) Watermelon fruit rot, caused by *Phytophthora parasitica*, in Texas. *Plant Disease Reporter* **38**, 854 illus.
6 NOVIELLO C., CRISTINZIO G. & ALOJ B. (1977) Una grave malattia della zucca in Campania. *Annali della Facoltà di Scienze Agrarie della Università degli Studi di Napoli Portici* **11**, 11–22 illus.
7 PONTIS R.E. (1945) *Phytophthora capsici* en frutos de zapallito de tronco. *Revista Argentina de Agronomía* **12**, 17–21 illus.
8 TOMPKINS C.M. & TUCKER C.M. (1937) *Phytophthora* rot of honeydew melon. *Journal of Agricultural Research* **54**, 933–944 illus.
9 ULLASA B.A. (1984) Two post-harvest diseases of water-melon caused by *Phytophthora nicotianae* and *Fusarium oxysporum*. *FAO Plant Protection Bulletin* **32**, 145 illus.
10 WIANT J.S. & TUCKER C.M. (1940) A rot of Winter Queen watermelons caused by *Phytophthora capsici*. *Journal of Agricultural Research* **60**, 73–88 illus.

PINK MOULD ROT of melons and watermelons caused by ***Trichothecium roseum*** **Link**

37

38

OCCURRENCE Pink mould rot has been recorded on melons and watermelons in India (8,9), on melons in the USA (10), and on melons imported from South America (10). The author has observed the disease on melons imported into the UK from Spain and Chile. The causal fungus also occurs on melons in France (1) and in Israel (2).

SYMPTOMS Lesions form at the blossom-end, stem-end or side of the fruit, and may extend over much of the surface. Affected skin becomes somewhat tough and shrivelled, and a viscous liquid may ooze from the lesion. Diseased flesh is spongy, slightly brown and extremely bitter in taste. Under humid conditions there is profuse development of salmon-pink spores (3,5,8).