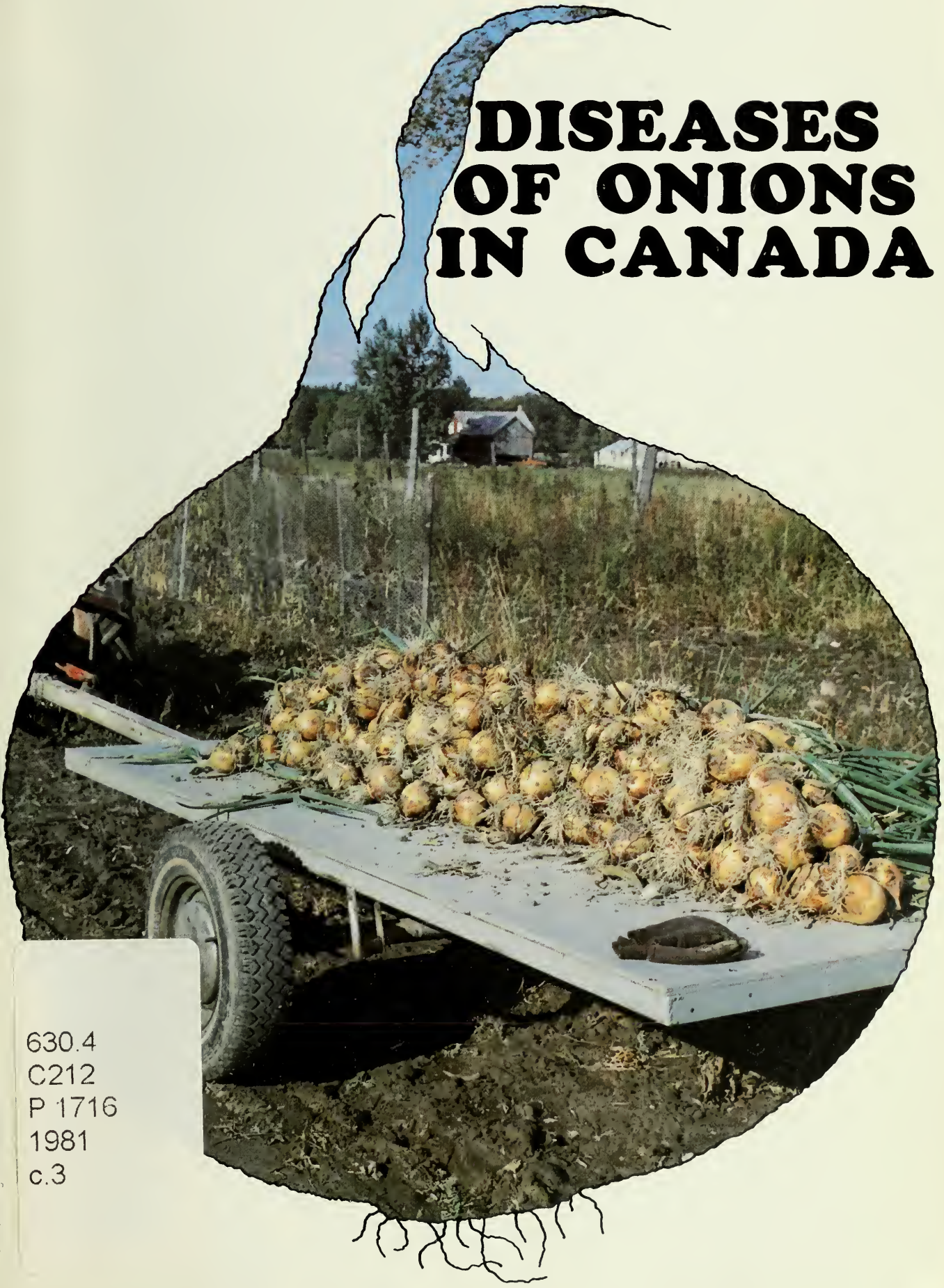
Agriculture
Canada

Publication 1716

DISEASES OF ONIONS IN CANADA



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PUBLICATION 1716E, available from
Information Services, Agriculture Canada, K1A 0C7

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Cat. No. A43–1716/1981E ISBN: 0-662-11186-9
Printed 1981 8M–4:81

Aussi disponible en français

DISEASES OF ONIONS IN CANADA

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INTRODUCTION

Onions are an important vegetable crop in Canada. Some 3700 ha are planted annually, and average yields are about 25 t/ha. The bulk of the crop goes to the fresh market, and the remainder is used for processing. Canada is not self-sufficient in its onion supply; imports, mainly from the United States, are four or five times as high as exports.

The onion is a cool-season vegetable that is well adapted to areas with long, cool growing seasons. The seed germinates at temperatures of 8°C or more. Cold, damp soil delays germination and growth, providing favorable conditions for seed rots and seedling diseases.

Onions need deep, loose, fertile soils with good water-holding capacity for plant development. Well decomposed, adequately drained organic soils are particularly suitable for them. In Canada approximately 80–90% of the onion crop is grown on organic soils. Ontario and Quebec lead the country in production.

Onion leaves develop quickly when the days are short and cool at the beginning of the growing season. The bulb forms at day lengths of 12–16 hours, depending on the cultivar. The yield therefore depends on the number of leaves present at the time of bulb formation and the thickness of the leaves at the base.

An abundant, healthy crop is largely a matter of effective disease control. To prevent or control diseases, it is important to be able to identify them as soon as the first symptoms appear.

This publication is therefore intended to provide descriptions of the main onion diseases in Canada and to recommend preventive measures.

CAUSES OF DISEASES

Most plant diseases are caused by fungi, bacteria, nematodes, mycoplasmas, and viruses, but unfavorable environmental conditions can also cause disorders called physiogenic diseases.

Fungi

Fungi are mostly microscopic plants that depend on other plants or decaying organic matter for their existence. Generally, fungi produce large numbers of spores, which are carried to their host-plants by wind, rain, insects, machinery, or man. Under favorable conditions of temperature and moisture, the spores germinate and infect healthy plants. Between growing seasons, many fungi survive in plant residues or in the soil as dormant spores, mycelia, or sclerotia.

Bacteria

Bacteria that attack plants are microscopic single-celled, rod-shaped organisms that multiply very rapidly. Often they appear as a secretion on the surface of diseased plants. In other cases the bacteria are released when the diseased tissue breaks down. They are then carried to other plants by splashing rain, insects, or man.

Nematodes

Nematodes are microscopic wormlike organisms that live in the soil. If they move into the roots of the plant, they are called endoparasites. If they feed on the roots from the outside, they are known as ectoparasites. When nematodes are present in large numbers they weaken the plants, reducing their yields. The root-knot nematode produces swellings, galls, or knots on the roots of carrots, lettuce, tomatoes, onions, and some other plants.

Mycoplasmas and viruses

Mycoplasmas and viruses are the smallest infective agents that cause diseases in plants. They are invisible under an ordinary microscope, but their shape and size can be determined with an electron microscope. They are composed of complex protein substances and multiply rapidly in the plant. They are transmitted in various ways, such as by insects, through physical contact, or sometimes in seeds.

Adverse environmental conditions

Some diseases are caused by adverse environmental conditions that seriously affect plant growth. These factors include extreme temperatures or excess moisture, unbalanced nutrition, deficiency or excess of minerals, acidity or alkalinity of the soil, poor drainage, or air pollution.

GENERAL CONTROL MEASURES

The purpose of disease control for cultivated plants is to limit economic losses and protect the value of the crop. Control measures are justified to the extent that their cost, in terms of money and effort, is less than the losses caused by diseases. The control measures chosen must also fit in with the production program. Because it is generally easier and more advantageous to prevent diseases than to cure them, crop sanitation

should be practiced. Methods include crop rotation, fungicide treatment of seed and foliage, soil fumigation, and use of resistant cultivars.

Crop sanitation

Some organisms that cause foliar diseases can survive and complete their life cycle on decaying plant material. The destruction of crop debris and residues of infected plants by burning, deep plowing, or other means prevents infection sites from developing.

The elimination of weeds in and around fields reduces the spread of certain diseases, because some weeds are reservoirs of viruses and mycoplasmas and often shelter the insects that disseminate them, such as the aster leafhopper, vector of the mycoplasma that causes aster yellows.

Crop rotation

Crop rotation makes it possible to eliminate certain diseases, when the crops that follow the main crop are not susceptible to the same diseases. This practice prevents the development or excessive buildup of soil-borne organisms that are difficult or too costly to control by use of chemicals.

The length of a rotation depends on how long an organism can survive in the absence of its host crop. Certain organisms such as those that cause foliar blights survive in crop residues for a limited time, so that a 2- or 3-year rotation should be sufficient to prevent the inoculum from building up.

Nematodes and certain other soil-borne organisms such as those that cause white rot and smut can survive almost indefinitely in the soil. For this reason, a rotation of 5 years or more is necessary to reduce the amount of inoculum. However, such a rotation is often impractical or not very effective, especially because some disease organisms also multiply on weeds.

Fungicide treatments for seed and foliage

Seeds should be treated with fungicide to prevent damping-off and smut, which are caused by fungi living on the seed or in the soil. Coat the seed completely with fungicide before planting, taking care to follow the manufacturer's instructions. This treatment is effective against fungi on the seed surface and improves the plant stand.

Foliar diseases are difficult to control once they have become established in a field. Fungicide treatments merely prevent them from developing or spreading to other plants or other fields. It is therefore a recommended practice to apply a protectant fungicide before diseases appear, to prevent excessive buildup of the inoculum. Treat crops at intervals of

7–10 days, depending on weather conditions or disease forecasts, and follow provincial recommendations.

Fumigation for nematode control

Before fumigating, you must weigh the cost and effectiveness of the treatment against the value of the crop and expected benefits. Many carrot and onion growers now use fumigation, together with a good program of crop rotation. Consult a nematologist to determine the level of the nematode population before you fumigate. In addition to eliminating nematodes, fumigation also has the advantage of reducing populations of harmful bacteria and fungi, soil insects, and weeds.

The soil can be fumigated in either fall or spring. To avoid delays in planting, fall fumigation is preferable. The soil must be slightly moist and the temperature at the 20-cm depth should be at least 5°C. The soil must also be free from undecomposed crop residues. Carefully follow provincial recommendations and manufacturer's directions concerning the rate and method of application. After treatment, the soil must be sealed by watering, leveling with boards, or packing. If you fumigate in the fall, leave the packed soil undisturbed until spring cultivation. With spring fumigation, allow the fumigant about 10 days to work. Then the soil has to be aerated for at least 1 week before planting, especially if it is cool and wet. *Do not use fumigants containing bromine, because they are toxic to onions.*

Resistant cultivars

The use of resistant cultivars is the most effective and economical method of controlling plant diseases. Often it is the only way of eliminating diseases caused by soil-borne organisms. Some diseases are resistant to all treatments and probably will not be controlled until new resistant cultivars are developed. At present, few such cultivars exist, but research is under way to develop new cultivars resistant to one or more diseases.

FUNGUS DISEASES

Purple blotch (tache pourpre)
Alternaria porri (Ell.) Cif.

Purple blotch is a common disease of onions and it can be very destructive under favorable climatic conditions. It also affects leeks and shallots.

The causal fungus is *Alternaria porri* (Ell.) Cif., which can attack all above-ground parts of the plant and also the bulb. The first blotches

appear on the oldest leaves. Originally they are small, elongated, sunken, and whitish, generally with a purple center (Fig. 1). Under favorable conditions, these blotches enlarge, join together, and become covered with the black fruiting bodies of the fungus. Finally the leaves wither. On onions grown for seed, the flower stem may be attacked and destroyed. The bulb can also be affected at harvest when the fungus enters through injuries or at the neck, causing a dark yellow or wine-red spongy rot in storage.

The fungus overwinters on the residues of infected leaves. In the growing season, it forms spores and infects plants during long wet spells. However, temperature has little effect on it.

Control measures

Control measures are the same as those recommended for leaf blight and neck rot.

Neck rot and gray mold rot (pourriture du col et moisissure grise)

Botrytis allii Munn, *B. squamosa* J. C. Walker, and *B. cinerea* Pers.

The causal fungi of neck rot are *Botrytis allii* Munn and *B. squamosa* J. C. Walker, which live only on plants of the genus *Allium* (onions, garlic, shallots, chives, and leeks). Gray mold rot is caused by *B. cinerea* Pers., a polyphagous fungus that occurs widely in nature.

Neck rot is mainly a storage disease, although infection originates in the field. It begins with a softening of the tissues in the upper part of the bulb, especially around the neck, and progresses gradually to the base. The infected tissues are brownish and soft, as if they had been cooked (Fig. 2). In a humid atmosphere, a typical gray mold grows on the affected parts. Often this mold can be seen only after removal of one or two outer scales or layers of the bulb. Small black sclerotia can be seen encrusted on the shriveled tissues (Fig. 3).

Gray mold rot produces a mycelial mat similar in appearance to that of neck rot, although it may be found on all parts of the bulb (Fig. 4).

The causal organisms of neck rot and gray mold rot overwinter in the soil on onion crop residues and constitute a source of inoculum in the following season. *B. squamosa* also causes leaf blight during the season. The bulb is infected at the end of the growing season, either through the neck (when the leaves die back) or through injuries during harvest.

The disease is especially likely to occur when the fall is rainy and the soil is too rich in nitrogen. These conditions slow down the withering of the leaves and curing of the neck.

Control measures

- Follow a fungicide spraying program to protect foliage adequately, according to provincial recommendations and disease forecasts.
- Harvest onions at full maturity.
- Harvest the crop in dry weather and air-dry the onions before storing, to allow injuries to heal quickly.
- Store at a temperature of 0°C and a relative humidity of less than 70%.
- Do not apply too much nitrogen fertilizer.

Leaf blight (brûlure de la feuille)
Botrytis squamosa J. C. Walker

Leaf blight is a common disease of onions and an important one, because it can rapidly damage foliage.

The disease appears on the oldest leaves as oval whitish or yellowish spots, 1–3 mm in length, slightly sunken and surrounded by a silver halo (Fig. 5). These spots extend through the thickness of the leaf blade and are easily visible inside the leaf when it is opened. These symptoms are distinct from the leaf flecks caused by *B. cinerea*, which are small surface spots without a halo.

When the spots are numerous and climatic conditions are favorable, a blight develops. The leaf tips turn brown and die back, making the blight easy to recognize (Fig. 6). The disease progresses rapidly, damaging the foliage severely and preventing normal bulb formation, so that yield is reduced.

On the tips of dead leaves the fungus produces numerous spores, which are transported by the wind and cause new infections. The fungus overwinters in the form of sclerotia in crop residues.

Leaf blight develops very quickly during long spells of warm, humid weather in midsummer. Frequently, pollution problems and ozone injury also occur at such times. The fungus that causes leaf blight can often aggravate ozone injury (Fig. 22).

The fungus can also proliferate in storage and cause a neck rot (see neck rot).

Control measures

- Follow a fungicide spraying program for complete foliage protection, according to provincial recommendations and disease forecasts.
- Pick up and destroy crop debris.
- For onions in storage, follow the recommendations for neck rot.

Smudge (anthracnose)
Colletotrichum circinans (Berk.) Vogl.

Smudge is a disease caused by the fungus *Colletotrichum circinans* (Berk.) Vogl., and it occasionally occurs on white onions at the time of harvest and storage. Small dark green or black spots appear around the neck of the onion and on the outer scales of the bulb. They are often grouped or arranged in concentric rings (Fig. 7). The diseased bulbs have a lower market value. In some cases, when the onions are poorly prepared for storage and stored under very moist conditions, the spots spread and appear on the inner layers of the onion in the form of small yellow lesions that grow larger and join together. The bulbs then shrivel and may sprout prematurely.

The disease is transmitted by contaminated onion bulbs kept for planting. The fungus can also survive in the soil for several years without its host, either as a saprophyte or as a stroma. The disease appears in warm wet weather, when rains spread the conidia produced by the fungus. Yellow and red onions are resistant to smudge.

Control measures

- Let onions dry out completely at harvest before storing.
- Store the dry onions at a temperature of 0°C and relative humidity of less than 70%.

Fusarium bulb rot (pourriture basale fusarienne)
Fusarium oxysporum Schlecht. f. sp. *cepae* (Hanz.) Snyd. & Hans.

Fusarium bulb rot is caused by a soil fungus, *Fusarium oxysporum* Schlecht. f. sp. *cepae* (Hanz.) Snyd. & Hans., which attacks only the *Allium* genus (onions, garlic, shallots, chives, and leeks). Onion monoculture on organic soils is particularly conducive to the disease.

The pathogen attacks the onion bulb in the root area, producing a firm pinkish brown rot that later becomes covered with a whitish mycelium (Fig. 8). The first symptoms of the disease are a yellowing and withering of the foliage. The plants can be pulled out easily, revealing decay of almost all the roots. When the infection occurs late, the symptoms are visible only in storage.

The fungus survives for several years in the soil in the form of chlamydospores or as saprophytes on crop residues. The disease is more serious when the soil temperature is 25–28°C and soil moisture is high.

Control measures

Like most soil organisms, this pathogen is difficult to eliminate.

- Practice a 3-year rotation with nonsusceptible crops such as carrots, spinach, lettuce, or beets.
- Choose cultivars recommended for their resistance to fusarium bulb rot.
- For onions in storage, follow the recommendations given for neck rot.

Downy mildew (mildiou)
Peronospora destructor (Berk.) Casp.

The mildew caused by *Peronospora destructor* (Berk.) Casp. is a disease that can rapidly destroy the foliage of *Allium* plants and thus prevents the formation, ripening, and storage of onion bulbs. The disease is very damaging to onion seed crops when the flower stem is destroyed before the seeds ripen.

The causal pathogen attacks the oldest leaves. The first signs are elongated patches varying in size and slightly paler than the rest of the foliage. Under moist conditions, these areas become covered with a violet gray down (Fig. 9), which may even spread to surrounding healthy tissues if damp weather persists. Often the leaves fold over at the affected area, and the leaf tips wither. In dry weather the down disappears and the spots thin out, but the down reappears and causes new lesions on neighboring tissues when the weather turns wet again. Frequently, another fungus (*Stemphylium botryosum* Wallr.), brown to black in color, establishes itself on the primary lesions and may even partly mask the mildew symptoms. In certain cases, when the plants are grown in severely contaminated soil or are produced from infected sets, the disease spreads through the whole plant and the fungus grows profusely within the leaves and bulbs. The plants are dwarfed and the leaves are pale green, deformed, and often covered with the violet down of the fungus.

Mildew infection needs a particular set of climatic conditions. To begin an infection the disease requires cool temperatures and the presence of water (rain or dew) on the surface of the leaves. A few hours of dry sunny weather are all that is needed to stop an epidemic. The fungus overwinters in infected crop residues as oospores and also persists from one year to another as mycelium in infected bulbs in storage.

Control measures

- Do not plant mildew-contaminated sets.
- Practice a 2-year rotation without any *Allium*.
- Follow a regular program of fungicide spraying on the foliage based on climatic conditions or provincial recommendations and disease forecasts.

- Destroy infected crop debris after harvest to eliminate an important source of inoculum.
- Remove refuse heaps of onions culled from storages.

Pink root (racine rose)
Pyrenochaeta terrestris (Hans.) Gorenz, J. C. Walker & Larson

Pink root is caused by the soil fungus *Pyrenochaeta terrestris* (Hans.) Gorenz, J. C. Walker & Larson, which also attacks leeks, garlic, shallots, and chives, but generally does not cause serious damage to these crops in Canada. The chief effect of the disease is to reduce bulb size.

The pathogen attacks the roots, causing affected plants to yellow and wither. For a sure diagnosis, pull up diseased plants. They pull out easily, revealing a substantially reduced root system. The remaining roots have a typical pink color, which turns to red, then purple, and finally through brown to black (Fig. 10). Generally, the disease appears in patches in the field, or on isolated plants.

The fungus can survive in the soil for several years in the absence of host plants. It attacks the roots mainly when the temperature of the soil rises to 26°C. If the temperature drops, the plant can recover by forming new roots and resuming vegetative growth.

Control measures

- Practice a rotation several years long without *Allium*, if the disease becomes a problem.

White rot (pourriture blanche)
Sclerotium cepivorum Berk.

White rot is a serious onion disease caused by *Sclerotium cepivorum* Berk. It is still not widespread in Canada. The disease appears on isolated groups of plants in fields and generally at the beginning of bulb formation. Young plants may also be affected. The oldest leaves yellow, droop, fall to the ground, and die. A soft rot gradually destroys the bulb and roots. The affected parts are covered with a thick white mycelial mat bearing numerous small black sclerotia (Fig. 11). These sclerotia allow the fungus to survive for at least 4 or 5 years in the soil in the absence of the host plant. Substances excreted by onion roots cause the sclerotia to germinate and the fungus then infects the roots.

White rot develops more quickly in cool weather (20°C) and with low moisture. The disease spreads from plant to plant through root contact, which explains why diseased plants occur in patches in the field. The

disease is spread more quickly by sclerotia when they are dispersed in the field by workers, tools, machinery, or runoff water.

In storage, the disease continues to develop on the affected bulbs and spreads to the healthy bulbs.

Control measures

White rot remains difficult to control. Damage may be serious one year and nonexistent the next.

- Practice a rotation of at least 4 or 5 years.
- Incorporate a specific fungicide into the soil before planting, according to provincial recommendations. This treatment can be used on small contaminated areas.

Smut (charbon)
Urocystis magica Pass. ap. Thüm.

Smut is a serious and widespread disease of onions and is caused by a soil fungus, *Urocystis magica* Pass. ap. Thüm. The infection often causes considerable losses at the seedling stage.

The first symptoms of the disease appear on the cotyledons and young leaves in the form of longitudinal blisters, which are blackish with a silver sheen and contain the fruiting bodies of the fungus (Fig. 12*a*). The seedlings often die before emergence. If the plants survive, the disease becomes systemic and they remain at a vegetative stage for the whole growing season. The bulbs in process of formation also become covered with blackish lesions (Fig. 12*b*) and are open to attack by other organisms that cause secondary rots. When the skin of the blisters splits, millions of fungal spores are released and fall to the ground, where they remain infectious for many years. Onions are susceptible to smut for a very short time in their life, that is, between germination and emergence. After they have emerged (first-leaf stage), the plants become resistant. Periods of cold, damp weather in the spring can delay plant emergence, creating conditions that favor smut infection. If the weather is warm and dry, the onions germinate rapidly and thus escape the disease. Transplanted onions are not affected by smut.

Control measures

- Coat the seed completely with a systemic fungicide to protect it during germination and emergence. Follow provincial recommendations.
- Practice rotation in order to prevent gradual infestation of the soil.
- On contaminated soil, grow onion transplants.

BACTERIAL DISEASES

Soft rot (pourriture molle)
Erwinia carotovora (L. R. Jones) Holland

Soft rot affects most vegetables grown in Canada, and is frequently found on onions in storage or in transit. Occasionally, it may develop directly in the field, especially at the end of the season, after heavy rains and when the leaves are dying.

The causal pathogen is a bacterium, *Erwinia carotovora* (L. R. Jones) Holland, which enters the bulb through the neck when the leaves wither, or through mechanical injuries or damage caused by the onion maggot, or in combination with other bulb diseases. The bacteria within the bulb first cause a softening of the tissues of one or more layers, which become spongy, watery, and pale yellow to grayish. Later the whole interior of the bulb breaks down and forms a sticky mass. When the bulb is squeezed, a viscous liquid oozes from the neck, giving off a characteristic foul odor.

The main source of contamination is in the soil. The bacteria survive on infested crop residues in the soil and are then spread by rain. They multiply very quickly in warm wet weather. The infection continues when the temperature is above 3°C in storage or in transit. The disease may be transmitted from one bulb to another when the humidity is too high.

Control measures

- Control the onion maggot, which causes injuries to bulbs, according to provincial recommendations.
- Do not damage bulbs during harvest.
- Store onions only when perfectly dry.
- Store the crop at a temperature of 0°C and a relative humidity of less than 70%.
- Provide adequate ventilation during storage.

Slippery skin and sour skin (pourritures bactériennes)
Pseudomonas alliicola Burkh. and *P. cepacia* Burkh.

These two bacterial rots of onions have rarely appeared in Canada, although they are found in some regions of the United States.

The causal organisms, *Pseudomonas alliicola* Burkh. and *P. cepacia* Burkh., seem to be specific to the onion and can be distinguished from one another only by the symptoms that they cause on affected bulbs. The common symptoms are a softening of the bulbs around the neck at the onset of infection. With an infection of *P. alliicola* the rot spreads from the neck to the base of the bulb, where the infection is transmitted from one fleshy scale to another until it invades the central part. The center

becomes watery and has a consistency like that of cooked tissue (Fig. 13). Simple pressure at the base of the bulb causes the rotted portion to slide out through the neck, hence the name slippery skin. The rot caused by *P. cepacia* is found on the outer layers without necessarily affecting the surface skin of the bulb. The affected tissues become yellow and viscous, but they are not watery (Fig. 14). The central portion also slides out if the bulb is pressed, but it is firm. The rot has an acrid odor, hence the name sour skin.

The life cycle of these organisms is still rather obscure, but when the weather is warm, they reproduce very quickly. They seem to spread and infect onions in the same way as bacteria that cause soft rot.

Control measures

The control measures are the same as those recommended for soft rot. In addition, wet onions should be dried artificially with forced heated air before being stored.

NEMATODE DISEASES

Root knot (nodosité des racines) *Meloidogyne hapla* Chitwood

Root knot is caused by the nematode *Meloidogyne hapla* Chitwood, which is common in vegetable-growing areas, especially in organic soils. When populations are high, they cause considerable damage to many crops, including onions.

Infested fields show patches of uneven, slow, sparse growth. The affected plants are stunted and have pale foliage. In areas where the nematodes penetrate the roots, the injured tissues react by producing knots or small swellings and there is an abnormal abundance of rootlets. The plant cannot absorb water and nutrients well, and the onion bulb is often smaller than normal (Fig. 15).

In the soil the young larvae are microscopic and wormlike in shape. They enter the host plant and feed there. At maturity, the females are distended and pear-shaped and lay hundreds of eggs in a gelatinous mass on the surface of the roots.

The warm summer months are particularly well suited to reproduction of this nematode, and depending on the temperature, several generations may be produced. The greatest infestation occurs at a temperature of 22–24°C. Alternate freezing and thawing help to destroy the larvae. Soil moisture is also important, and few larvae and eggs survive in flooded soils.

The larvae do not move around much in the soil during the growing season. They are mainly transported by runoff water, by disturbance of

the soil in infested plantings, and in bulbs used for seed production. The root-knot nematode reproduces profusely on susceptible crops or weeds.

Bloat (enflure)
Ditylenchus dipsaci (Kühn) Filip.

Bloat is caused by the nematode *Ditylenchus dipsaci* (Kühn) Filip. This species can attack a large number of cultivated and wild plants, and is often harmful to plants of the *Allium* genus, such as onions, garlic, leeks, and shallots. In heavily contaminated soil, onions may be attacked in their earliest stages of growth and suffer considerable damage. Shortly after emergence, the base of the onion looks swollen and small yellowish warts appear on the leaves, which are bent and deformed (Fig. 16*a*). The leaves become chlorotic and die back from the top, causing premature death of the young plants. On older plants, the leaves fall prematurely and the bulb softens starting at the neck. Affected onions become spongy, the disease being characterized by brown areas between the bulb layers (ring disease). Splitting or cracking of infected bulbs is one of the most easily recognizable symptoms. Frequently the bulb bursts and rots very quickly (Fig. 16*b*). In storage, the nematodes continue to develop in the tissues, encouraging invasion by secondary organisms that cause bulb decay.

The nematode overwinters as desiccated larvae on seed and in onion crop residues left in the field or in storage. The seed is infected from diseased bulbs transplanted for seed production. The larvae and adults enter the host plant through the stomata or through cracks or injuries in the tissues, or by piercing the skin with their stylet. They reproduce in the tissues and complete their life cycle in 3 or 4 weeks. Several generations succeed one another in a growing season.

This nematode can survive for several years in a dormant state under droughty conditions and resume its activity when the environment again becomes suitable. It can be carried over long distances in soil adhering to farm implements, as well as by the wind or in crop residues, containers, and infected seeds and bulbs.

Control measures

It is easier and more economical to prevent an infestation of nematodes than to get rid of them.

- Use healthy seed.
- Practice a 3-year rotation with resistant crops (corn or grains). The population density of nematodes declines quickly in the absence of host plants.
- Fumigate thoroughly with a recommended nematocide if the population exceeds 5–25 *Ditylenchus dipsaci* nematodes, or 2000 *Meloidogyne hapla* nematodes, per litre of soil.
- Reread the section on fumigation for nematode control and follow provincial recommendations.

VIRUS DISEASE

Yellow dwarf (nanisme jaune)
Onion yellow dwarf virus

Yellow dwarf disease of onions occurs in several countries but is not widespread in Canada, because it affects mainly onion seed crops and sets. It also occurs on shallots, garlic, leeks, and certain species of narcissus. The disease reduces the bulb yields of onions grown from seed if the infections occur in early spring, and it may lower seed production of onion seed crops by up to 50%. Bulbs from diseased plants keep poorly in storage.

The causal pathogen of this disease is the onion yellow dwarf virus. It is transmitted to onions by several species of aphids and may also be spread by mechanical means. Seeded onions are infected during growth. The first symptoms appear on the youngest leaves, which turn pale, and a large number of yellow streaks form along the veins. The leaves crinkle and flop over (Fig. 17). When an infected bulb or set is planted, the symptoms are even more apparent: the yellow streaks begin at the base of the first leaf and then appear on the other leaves as they emerge. Later there is more pronounced yellowing and the leaves crinkle, flatten, twist, and fall to the ground. The flower stem, which remains short, becomes streaked with yellow and twisted. Generally, the plant takes on a dwarfish, wilted appearance.

The virus is not spread by the seed, but infected bulbs always produce diseased plants. The virus overwinters in infected bulbs of onions, onion sets, shallots, or garlic. In the spring these infected bulbs become the chief sources of contamination, and the disease is transmitted mainly by aphids to seeded onions or other healthy plants.

Control measures

- Plant resistant cultivars in areas where infection is serious from year to year.
- Use a recommended insecticide to control aphids.
- Grow shallots, garlic, onion sets, and narcissus at a distance from a field of onions.

MYCOPLASMA DISEASE

Yellows or aster yellows (jaunisse)
Aster yellows mycoplasma (AYM)

Aster yellows is a widespread disease that affects a large number of cultivated and wild plants, including vegetables such as carrots, lettuce, celery, and onions. Onions, however, are less often affected than carrots or lettuce, although onion seed crops suffer much greater damage.

The causal pathogen is the aster yellows mycoplasma (AYM), which is transmitted to plants by the aster leafhopper, *Macrosteles fascifrons* (Stål).

On seeded onions, the symptoms begin with a yellowing at the base of the youngest leaves, which spreads toward the top. The leaves then flatten and become marked with yellow and green streaks, although they do not twist (Fig. 18). Seed crop plants show yellowing and abnormal elongation of the flower stem and pedicels, causing malformation of the floral cluster and sterility of the umbels.

The aster leafhopper is the most important vector of yellows. In Quebec the insect overwinters at the egg stage on winter cereals or grasses. In the spring the eggs hatch and the nymphs feed on their winter hosts. At the adult stage, the insects invade other crops before onion fields. They pick up the mycoplasma by feeding on infected perennial hosts and spread it to healthy plants.

Control measures

- Destroy perennial or biennial weeds on which the mycoplasma can survive. Such plants grow along roadways, ditches, fence lines, and in open fields.
- Reduce leafhopper populations by applying an effective insecticide to field headlands. This destroys leafhoppers found on weeds.
- Follow provincial recommendations.

PHYSIOGENIC AND OTHER DISORDERS

Sun scald (insolation)

During warm dry springs, a hot sun may at times raise the temperature at the soil surface to 65°C. This is particularly the case on dark soils, such as organic ones. The heat damages the sensitive young plants, killing the cells at the neck level. The injured tissues shrivel, strangling the neck (Fig. 19), and the plant wilts and withers. The seriousness of the damage

depends on the temperature at the soil surface and the tenderness of the plant tissues.

Control measures

Sun scald is a minor problem rarely encountered in onion crops. There is no practical solution.

- Seed as early as possible so that the plants soon outgrow the sensitive stage.

Physiological breakdown; translucent scales (tuniques translucides)

This physiological disorder of the onion is characterized by grayish, watery tissues of one or more layers or scales, which makes them appear translucent. Sometimes the condition affects all the layers, but most often, only the second and third fleshy scales. In cross section, the affected scales are brownish (Fig. 20).

Translucent scales can be confused with frost injury. However, frost always attacks from the outside in, and also affects the neck. Frost also produces areas of opaque white tissues within the translucent tissues. Finally, with frost injury, the skin is loose on the concave side of the affected layers and the tissues take on a granular texture.

The causes of translucent scales are unknown. The problem seems to be connected with storage, because it appears after harvest and worsens after 3 or 4 months of storage. Research has shown that onions kept at 5–10°C for a few weeks before final storage at 0°C are more subject to this disorder. Excessive relative humidity could also predispose onions to this problem.

Control measures

- Dry onions well and store as soon as possible at a proper temperature (0°C) and at a relative humidity of 65–70%.

Wind and pelting rain injury (dommages causés par le vent et la pluie)

Wind and pelting rain injury is caused mainly during storms, when raindrops driven by violent winds strike and injure the onion leaves. Damage is visible only on the side of the leaves onto which the wind blew the rain. Whitish to yellowish spots, round to irregular in shape and varying in size from 1 to 5 mm, are produced (Fig. 21).

Rain injury is generally not serious, but it is important to distinguish it from damage caused by *Botrytis* spp., ozone, or certain herbicides.

Ozone injury (dommages causés par l'ozone)

Ozone is a powerful oxidant that exists in small quantities in the air that we breathe. However, ozone can be produced in large quantities through the action of light on hydrocarbons and nitrogen oxide, formed through incomplete combustion of fuel in internal combustion engines. It can also be produced during electric storms. The concentration of ozone in the air can then increase enough to injure onions, which are considered to be sensitive to this pollutant.

Damage generally occurs on warm, hazy, humid, windless days in midsummer when pollution is high. The symptoms appear, however, 1–3 days later, on well-developed leaves, in the form of translucent flecks or small spots, which turn whitish (Fig. 22). These spots are sunken and irregular in shape and size. When they exist in large numbers, they coalesce to form patches of white tissues. The leaf tips then frequently wither. Generally, the young and oldest leaves are resistant. Injury is most evident on the side of the leaf directly exposed to the sun. The absence of a pale halo around the spots distinguishes ozone injury from the damage caused by *Botrytis* spp. Tissues affected by ozone are more susceptible to later attack by the *Botrytis* spp. that cause leaf blight. Both types of symptoms may appear simultaneously on the leaves.

Control measures

There is currently no control measure for this pollution problem.

Herbicide injury (dommages causés par les herbicides)

Improper use of herbicides can cause temporary or permanent injury to onions. Damage can occur when herbicides are applied at excessive rates or at an ill-considered stage of onion growth. With contact herbicides, burns and necrotic spots are produced (Fig. 23*a*) and the leaf tips wither. On the other hand, with translocation herbicides, the onions may yellow or the leaves may curl (Fig. 23*b*). Generally, the plants recover and the symptoms disappear over time. However, if the application rate is too high, the damage will be irreversible. Damage may also be observed if onions are grown where the previous year's crop was treated with a residual herbicide to which onions are susceptible.

Control measures

- To avoid injury, follow recommendations concerning the use of herbicides on onions.
- Know which herbicides were used on the crops preceding the onion crop.

Thrips injury (dommages causés par les thrips)

Thrips are tiny insects, almost linear in shape and yellow to pale brown in color. During warm, dry summers they are found in large numbers at the base of onion leaves. Thrips damage the leaves by rasping the surface skin to suck sap from the plant. Damage always occurs along the leaf veins and is characterized by tiny dark green spots at first, as a result of the rasping. The spots later turn white or silvery (Fig. 24). When these injuries are numerous they take the form of silvery longitudinal streaks on the leaves.

Thrips are very difficult to see on foliage with the naked eye. They develop very quickly in hot, dry weather. High populations of thrips can sometimes cause young leaves to wither. Rain and cool weather slow down population increases.

Control measures

- Use a recommended insecticide to control this insect. Insecticides used as surface treatments against the onion maggot are also effective in controlling thrips.

ACKNOWLEDGMENTS

The authors would like to thank specially the following people, who graciously contributed photographs for the publication: Dr. P. W. Johnson, Research Station, Agriculture Canada, Vineland Station, Ont. (Fig. 16*b*); and R. T. Wukasch and Dr. G. Hofstra, Department of Environmental Biology, University of Guelph, Guelph, Ont. (Figs. 22 and 23*a*).

FIG. 1 Purple blotch: elongated, sunken, whitish spots; purple center and black fruiting bodies of the fungus.

FIG. 2 Neck rot: brownish infected tissues and softening around the neck.

FIG. 3 Neck rot: grayish mold and black sclorotia on the outer layers.
FIG. 4 Gray mold rot: gray mycelial mat on the bulb surface.

FIG. 5 Leaf blight: oval spot, whitish to yellowish, surrounded by a silvery halo.

FIG. 6 Leaf blight: numerous small whitish surface spots, and dieback of the leaf tips.

FIG. 7 Smudge: small dark spots arranged in concentric rings that coalesce.

FIG. 8 Fusariam bulb rot: firm pinkish brown rot covered with whitish mycelium.

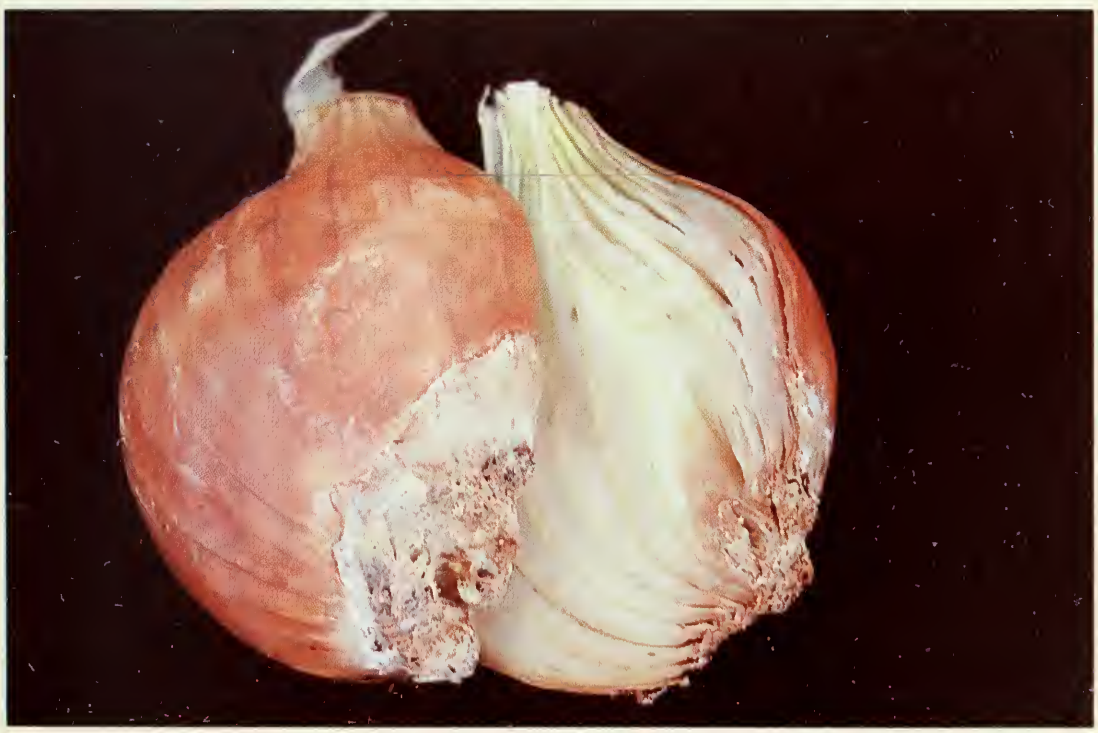

FIG. 9 Downy mildew: elongated pale green area covered with violet gray downy mycelium.

FIG. 10 Pink root: reduction of the root system. Note the pink, purple, then brown to black roots.

FIG. 11 White rot: soft rot under a white mycelial mat covered with numerous small black sclerotia.

FIG. 12 Smut: (*a*) on cotyledons and young leaves, blackish longitudinal blisters containing the spores of the fungus; (*b*) lesions on developing bulbs.

A B

FIG. 13 Slippery skin: watery rot of the bulb's inner layers.

FIG. 14 Sour skin: rotting of the bulb's outer layers. Affected tissues are not watery.

FIG. 15 Root knot: knots accompanied by an abnormal proliferation of rootlets. The infected bulb is the smaller one.

FIG. 16 Bloat: (*a*) swelling at the base of the onion, and bent and deformed leaves; (*b*) splitting of bulb.

A B

FIG. 17 Yellow dwarf: pale green young leaves. Older leaves are crinkled and folded downward.

FIG. 18 Yellows or aster yellows: yellowing at the base of the youngest leaves. Older leaves are flattened and marked with pale streaks; no twisting.

FIG. 19 Sun scald: lesions and strangling of the neck.

FIG. 20 Translucent scales: second fleshy layer showing watery texture and pale brown to grayish color.

FIG. 21 Pelting rain injury: irregular whitish spots of variable size.

FIG. 22 Ozone injury: numerous small translucent spots forming whitish patches, and dieback of the leaf tip.

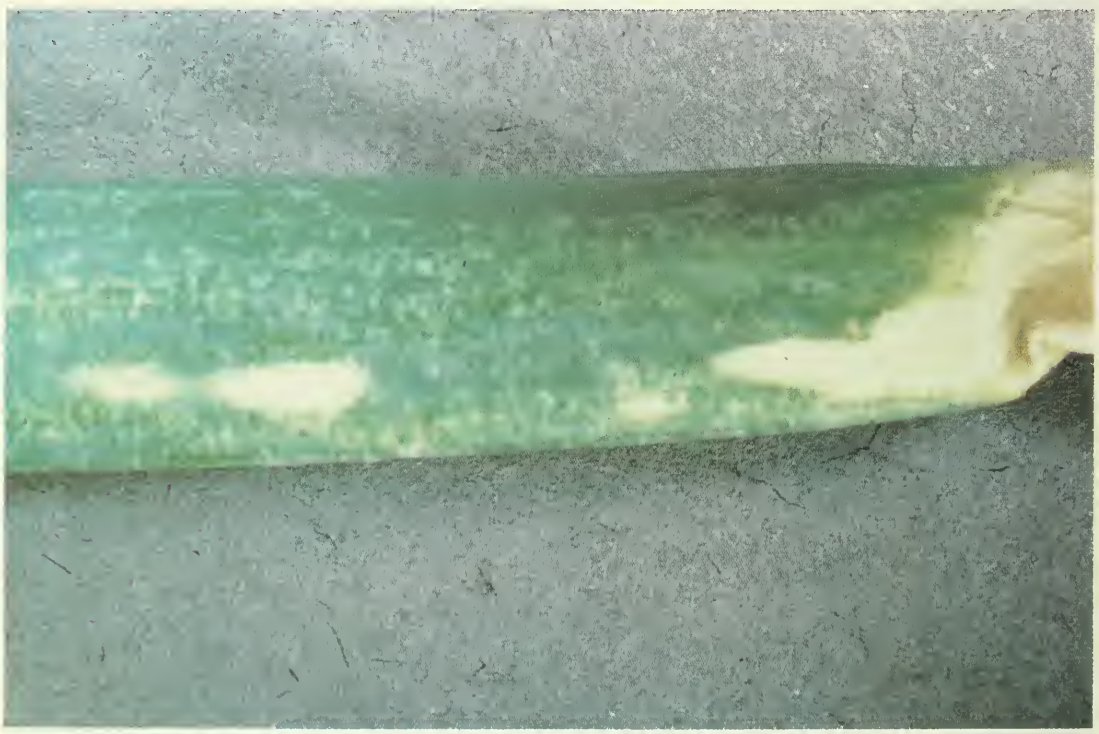

FIG. 23 Herbicide injury: (*a*) sunken necrotic spots caused by niclofen; (*b*) yellowing and twisting of the leaves caused by a translocation herbicide.

FIG. 24 Thrips injury: tiny dark green spots that turn whitish silver. Note a few thrips along the midrib of the center leaf.

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